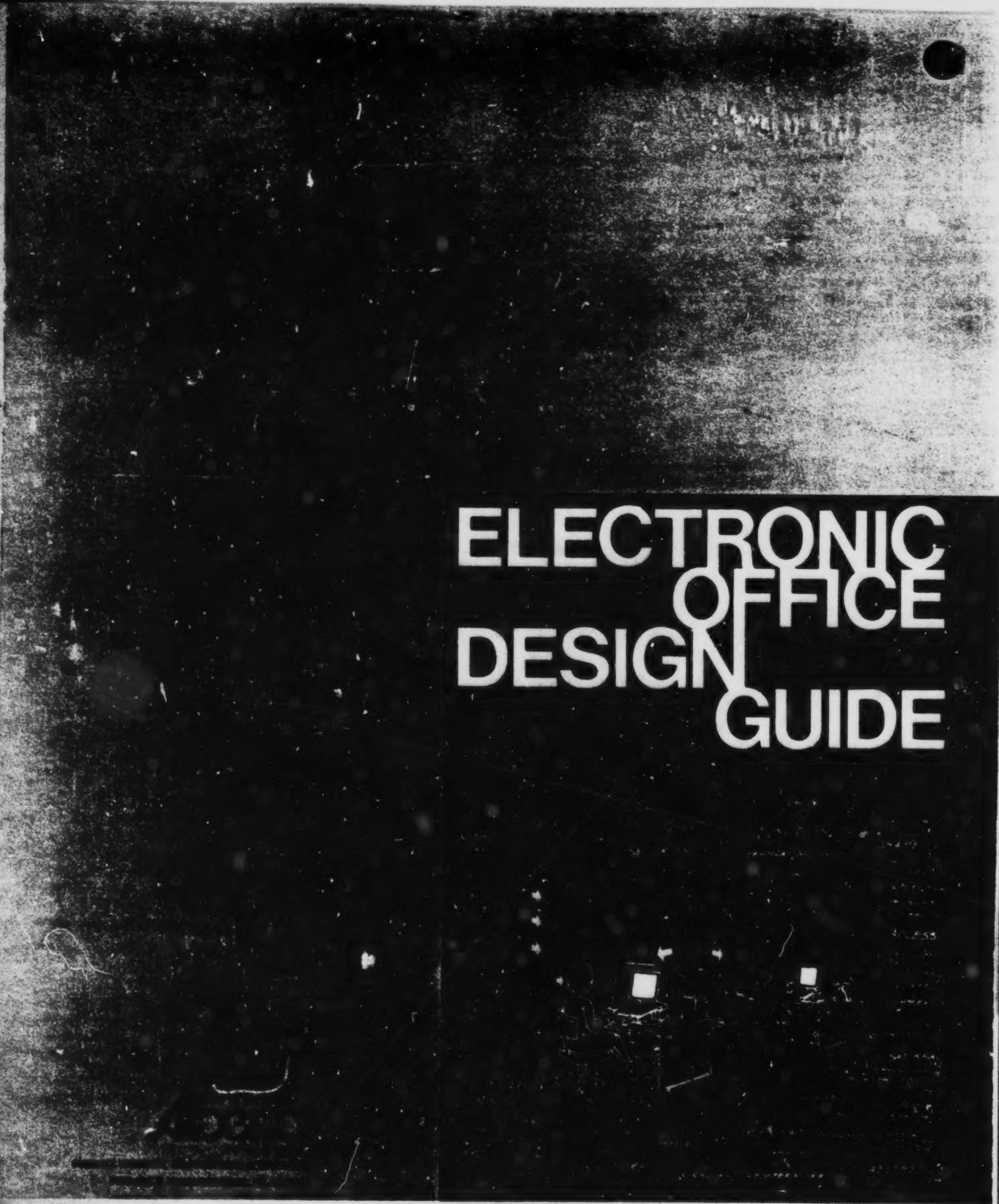

ELECTRONIC OFFICE DESIGN GUIDE

ELECTRONIC OFFICE DESIGN GUIDE

NOISE
HUMIDITY
DISTRIBUTION
REFLECTION
FUNCTION
SHAPE
SECURITY
VENTILATION
AIR QUALITY
SUBJECTIVE
EXTERNAL
WIRE MANAGEMENT
SOCIAL
AURAL
VISUAL
THERMAL
FIRE SAFETY
ERGONOMICS
STORAGE
ODOUR
ACCESS
COST
CLOTHING
SPATIAL
ILLUMINATION
ORIENTATION
CARE
FURNITURE
AESTHETICS
RADIANT TEMPERATURE

ELECTRONIC
OFFICE
DESIGN
GUIDE

PREFACE

"I am but a gatherer and disposer of other men's stuff"

Sir Henry Wotton, in his Preface to THE ELEMENTS OF ARCHITECTURE

Whatever else it does, the introduction of electronic technology into offices forces us to look again at how we function and what, if any thing, we can do about it. The electronic office brings promises of marvellous potential and threats of diminished influence as well as operational problems; hopes and threats simultaneously. Everything depends on how we seize the opportunities that are opening out and how we face the new challenges to our old positions. In fact, challenges and opportunities are so closely integrated, it is difficult to tell one from the other.

The introduction of the odd piece of equipment has a little effect on the environment:

- the extra heat generated can be ignored;
- the power consumption is only slightly increased;
- the extra space requirements can be accommodated by rearrangement of furnishings which can, in turn, be adjusted according to needs;
- the power, communication and data wires can be rolled and tucked away as neatly as possible; and
- reflections in the VDT can be masked with cardboard and tape.

As more equipment is added, a point is reached when the users and the environment reject the technology and a strategy has to be developed to meet the challenge head on. Somewhere between the first and twentieth machine, the heat output causes problems, the power fuses blow, we run out of space, the tangle of wires becomes reminiscent of a spaghetti factory and staff discomfort and fatigue set in.

It is abundantly clear that the users of the electronic office are becoming more and more demanding. It is equally clear that the introduction of electronic equipment into offices has far-reaching implications for designers, manufacturers, developer and clients:

- We will have to accept the users as "co-designers", whether we like it or not; to develop the program in detail and to evaluate design proposals of existing conditions;
- We will have to learn how to cope with a number of users with multiple, sometimes, conflicting interests;
- We will not be able to hide behind an unquestioned stance of "professional judgement"

- We have to present and share our ideas with the users and design professionals (architects, engineers, programmers, specification writers and interior designers), manufacturers and suppliers.

However much we open up the design process, we will still have a major share of the responsibility of finding ways to communicate with all those involved in the electronic office. The Electronic Office Design Guide is an attempt at developing a *lingua franca*, a basis for communication:

For the user and programmer: A checklist of items to be considered either in the development of design programmes or evaluation of facilities.

For the users, designers, furniture manufacturers and suppliers:
Detailed performance requirements with visual aids, where possible, and recommended criteria of what is desired regardless of how these requirements are achieved.

For users, building owners, designers:
Detailed performance requirements with extensive visual aids, for the environment in the electronic office. The additional requirements of the Electronic Office have been considered in the context of parallel developments with respect to energy conversation and growing demands for improved quality or the environment at work.

The Electronic Office Design Guide is a unique attempt by a team of specialists to interpret the knowledge and information in "burotics" research into requirements and criteria for design and evaluation. In making a useful contribution to the current debate on office automation this Design Guide performs a two-fold task: it acquaints the readers with the requirements of the electronic office and, at the same time, it summarizes the state-of-the-art of research in a variety of disciplines as they relate to the workstation and users.

While the scale and complexity of the team's efforts have been of necessity focussed to understanding emerging trends, our goal has been to be thorough and methodical in meeting our challenge of providing guidelines for the design of the electronic office.

The Electronic Office Design Guide has been a collaborative effort involving many Divisions and Branches of the Department and several Specialist Consultants. The support of the senior management of all Divisions has been constant and the project team is particularly grateful for this support.

s.m.
Calgary, August 1985

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thought Alice, "without pictures?"
Lewis Carroll

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ELECTRONIC OFFICE DESIGN GUIDE

1. INTRODUCTION

Much has been written about the "office of the future" - most of it speculative - and its implications for management, organizational development, activities, equipment and furnishings. There has been an element of continuity, though, between the "office of the past" (the manual office) and the contemporary office in terms of purpose, organization and system support requirements. And, in all likelihood, the "office of the future" (a further development of the electronic office, no doubt) will follow in this trend, reflecting the inherent conservatism of business and governmental organizations and the continuing need for the office as a place to process, transfer, store and retrieve information and to meet in conference.

Developments in offices have tended to enhance speed, capacity and the working environment. The changes in working habits which result from the introduction of electronic equipment have tended to highlight and intensify the limitations of the conventional office environment and work place, while creating additional problems.

The approach to the resolution of the problems of the electronic office cannot be haphazard. The concerns are with safety, health, comfort and efficiency of the electronic office workers in their working environment. It is not so much one factor (for example, lighting or the lack of it) but the multitude of factors and their interactions which determine the working conditions and potential source of problems in the electronic office. It is evident, then, that the approach to the resolution of problems must be comprehensive and systematic, embracing the arts and sciences of engineering (for the design and operation of the machines within the environment), psychology (man-machine interaction), physiology (to determine human capacities and limitations), and anatomy (to determine shape, size, strength, posture, motion, etc).

Comprehensive surveys(1,2) and research programs(3,4) have shown that the users of electronic equipment (such as visual display terminals (VDTs), printers and other computer accessories are subject to a disproportionately higher occurrence of problems than other clerical groups (Table 1). User dissatisfaction and discomfort invariably lead to reduced efficiency from the point of view of productivity, and often to impaired health. The primary cause has been attributed to *fatigue*, an easy word that is difficult to define. Fatigue in VDT users manifests itself in a variety of different ways:

- Muscular - pain, discomfort, stiffness of the neck, hands, arms, body, back, and legs;
- Mental (emotional, intellectual) - migraine, dizziness, irritability, and stress;
- Visual - eyestrain, visual irritation, disturbed acuity.

TABLE 1

Percentage of Clerical VDT Operators and Controls Subjects with Selected Health Complaints Showing a Significant Effect*

Health Complaints	Clerical VDT	Control Clerical Subjects
Skin rash	57	31
Irritability	80	63
Fainting	36	17
Nervous	50	31
Fatigue	74	57
Pain down arm	37	20
Stomach pains	51	35
Change in colour perception	40	9
Irritated eyes	74	47
Burning eyes	80	44
Blurred vision	71	35
Eye strain	91	60
Swollen muscles and joints	50	25
Back pain	78	56
Painful or stiff arms or legs	62	35
Painful or stiff neck or shoulder	81	55
Numbness	47	18
Neck Pressure	57	34
Difficulty with feet from standing long periods	49	35
Sore shoulder	70	38
Loss of feeling in wrists or fingers	33	11
Neck pain into shoulder	56	19
Hand cramps	49	16
Loss of strength in arms or hands	36	14
Stiff or sore wrists	47	7

* At 95 percent level of confidence or greater using a Chi Square test for homogeneity.

SOURCE: FRASER, M.M. "ERGONOMIC APPROACH TO THE VDT PLACE" WATERLOO 1981.

In the past, change in the type of work and the office environment was limited to upgrading and improving the existing. With the introduction of VDTs, the office environment in its relationship to the organization it serves must accommodate the impact of these dynamic new conditions. The office has become a place for a great variety of tasks; it is more than a place for work - it is a place that works. The problem is how to create a flexible, cost effective environment which promotes the safety and health of the users, facilitates and accommodates change, accepts growth and allows people to use their space effectively.

Each situation must be carefully analyzed, with specific and detailed information being obtained from a variety of sources. There is, however, a substantial and growing body of knowledge in the literature - engineering, ergonomic and design disciplines - which is relevant to the good planning and design of electronic offices. Although much remains to be discovered about the exact causes of and solutions to the problems, it is important to draw a general set of guidelines and recommendations that can be applied to all electronic offices. The Electronic Office Design Guide has been developed with the purpose of providing the basis for a comprehensive and systematic approach to the electronic office for:

- Appraisal of existing facilities;
- Input by users into programming, design and evaluation of new facilities;
- Guidelines to manufacturers of office furnishings and equipment;
- Future standards and legislation.

2. PROBLEM ANALYSIS

In developing the Electronic Office Design Guide, the emphasis has been on the furnishings and the working environment - the hardware and software of VDTs (and their erogonomic implications) being developed elsewhere. The market is progressively being overwhelmed by new designs and products to meet the needs of the workers in the electronic offices. For all involved with electronic offices, a problem exists with respect to the evaluation of the new products and the environment. The usual procedure has been to compare new designs with existing conditions and to require that the new products and environments should be at least as good as the existing ones in all essential characteristics.

This procedure is hardly satisfactory, especially for electronic offices, where working conditions are different enough to warrant a thorough analysis to assist in defining the needs and requirements which must be fulfilled in the facility. To this end, it is desirable to present, albeit in a synoptic manner, an analysis of electronic office operations(5).

Consider the elements of the electronic office operation which have an impact on the space, needs, support systems, growth potential, and so on:

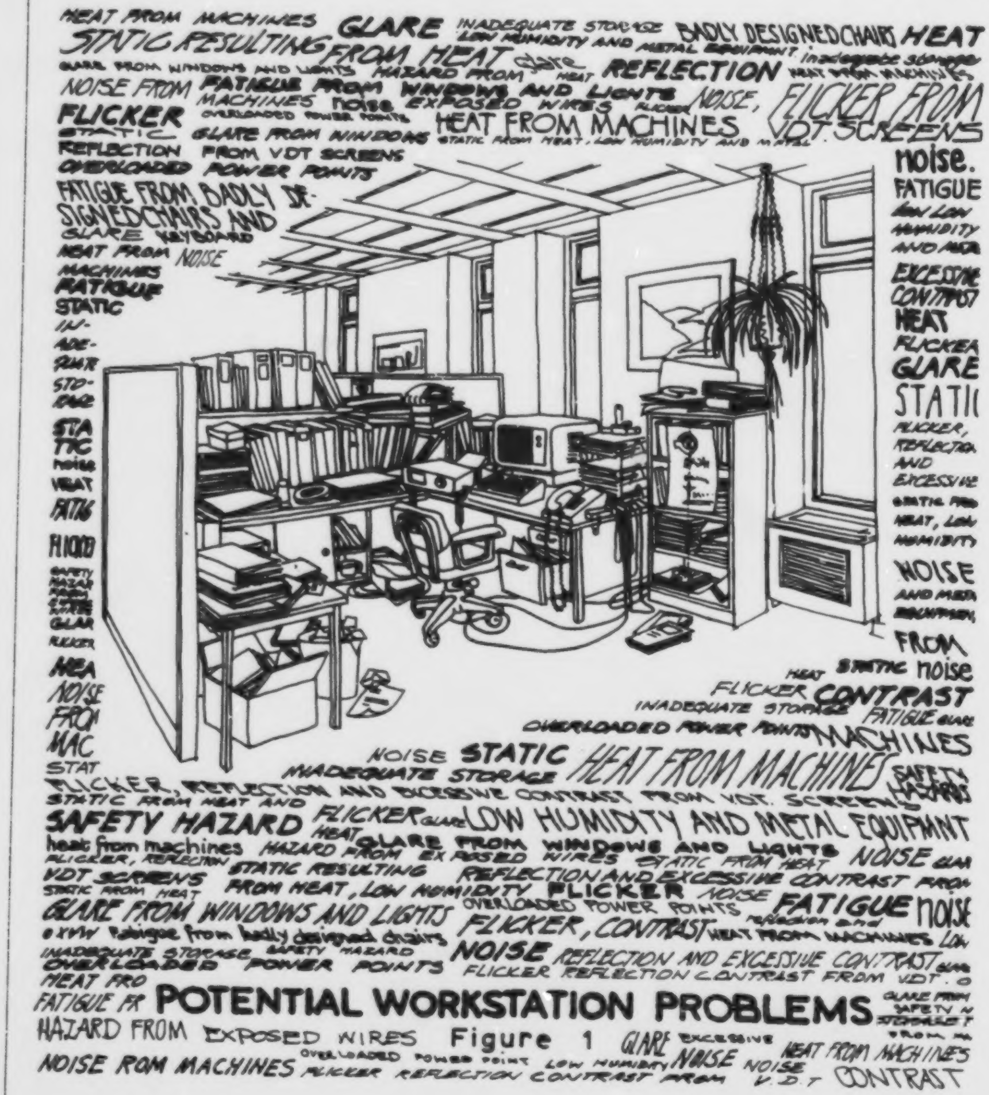
- Task - determining the need for equipment and workspace organization (word processing/data processing/enquiry and dialogue)
- User - essentially one of two types, professional or clerical. With the professional, the VDT is a tool used irregularly while the clerical user uses the VDT continuously.
- Workspace - comprising furniture, equipment, organization of work surfaces, cabled services (power, telephone and data), etc. . . .
- Environment - consisting of lighting, acoustics, heating and ventilation, air quality, office layout and decoration.

Support services for the electronic office operations as well as the need for greater flexibility in fitting out the space further complicates the problem. Ideas for resolving the electronic office problems vary. It is evident, however, that, no matter what approach is adopted, it will involve a multiple criteria analytical process.

It is, furthermore, clear that the existing office environment and furnishings do not adequately fulfill the performance requirements imposed by the interaction of the users with the workspace and the environment as they go about their tasks. As more equipment is added to existing offices, a point is reached when the environment rejects the technology. Somewhere between the first and twentieth machine, the heat output causes problems, the power fuses blow, and staff discomfort and fatigue set in. A way to reveal the importance of a suitable office environment and properly designed furnishings is to look at what can happen if they are not provided. (Figure 1)

3. PERFORMANCE REQUIREMENTS FOR ELECTRONIC OFFICES

There are two principal ways in which efficiency and successful implementation of electronic offices can be married to human needs and requirements: good performance requirements for the analysis and evaluation of the workplace and the environment, and the involvement of the users in the process. Consider the electronic office as a system in which the performance of its subsystems fulfill the requirements imposed on it by the tasks, users, workspace and environment. Evidently, there are many ways of breaking down the system into subsystems of performance parameters. The parameters in Figure 2 form the basis for the subsequent development of detailed performance requirements, criteria and test methods in the Electronic Office Design Guide. These parameters reflect the elements considered in the electronic office operation (environmental as well as user/workspace requirements) and economic factors. Furthermore, they correspond to well-established



POTENTIAL WORKSTATION PROBLEMS

Figure 1

HEAT FROM MACHINES GLARE INADEQUATE STORAGE BADLY DESIGNED CHAIRS HEAT
STATIC RESULTING FROM HEAT LOW HUMIDITY AND METAL EQUIPMENT inadequate storage
GLARE FROM WINDOWS AND LIGHTS HAZARD FROM glare HEAT REFLECTION HEAT FROM MACHINES
NOISE FROM FATIGUE FROM WINDOWS AND LIGHTS NOISE, FLICKER FROM
MACHINES noise EXPOSED WIRES FLICKER
FLICKER OVERLOADED POWER POINTS HEAT FROM MACHINES VDT SCREENS
STATIC GLARE FROM WINDOWS STATIC FROM HEAT, LOW HUMIDITY AND METAL
REFLECTION FROM VDT SCREENS
OVERLOADED POWER POINTS
FATIGUE FROM BADLY DESIGNED CHAIRS AND
GLARE KEYBOARD
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MACHINES
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STATIC noise HEAT FATIG FLICKER SAFETY HAZARD GLARE FLICKER
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noise.
FATIGUE
LOW LOW HUMIDITY AND META
EXCESSIVE CONTRAST
HEAT
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GLARE
STATIC
FLICKER, REFLECTION AND EXCESSIVE
STATIC FROM HEAT, LOW HUMIDITY
NOISE AND METAL EQUIPMENT
FROM
HEAT STATIC noise
FLICKER CONTRAST
INADEQUATE STORAGE FATIGUE GLARE
OVERLOADED POWER POINTS MACHINES
NOISE STATIC HEAT FROM MACHINES SAFETY HAZARD
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FLICKER, REFLECTION AND EXCESSIVE CONTRAST FROM VDT. SCREENS
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HEAT GLARE FROM WINDOWS AND LIGHTS
heat from machines HAZARD FROM EXPOSED WIRES STATIC FROM HEAT NOISE GLARE
FLICKER, REFLECTION STATIC RESULTING REFLECTION AND EXCESSIVE CONTRAST FROM
VDT SCREENS FROM HEAT, LOW HUMIDITY FLICKER NOISE
STATIC FROM HEAT OVERLOADED POWER POINTS FATIGUE noise
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NOISE ROM MACHINES OVERLOADED POWER POINT LOW HUMIDITY NOISE NOISE
FLICKER REFLECTION CONTRAST FROM V.D.T CONTRAST

disciplines in engineering (ergonomics, lighting, acoustics, electrical, structural, mechanical) - a consideration of great significance especially for the development of detailed performance requirements.

Consider also some of the recommendations of the Canadian Labour Congress[6] on workstation conditions:

- provide maximum flexibility, especially in shared work stations;
- reduce noise levels to a comfortable level;
- provide adjustable (by the workers) lighting levels to suit needs and tasks;
- reduce glare for both screen and keyboard;
- define minimum standards for screen characteristics such as size and colour of screen and characters, inter-linear and inter-character spacing, reflective surfaces, etc....
- require eye tests;
- improve privacy considerations.

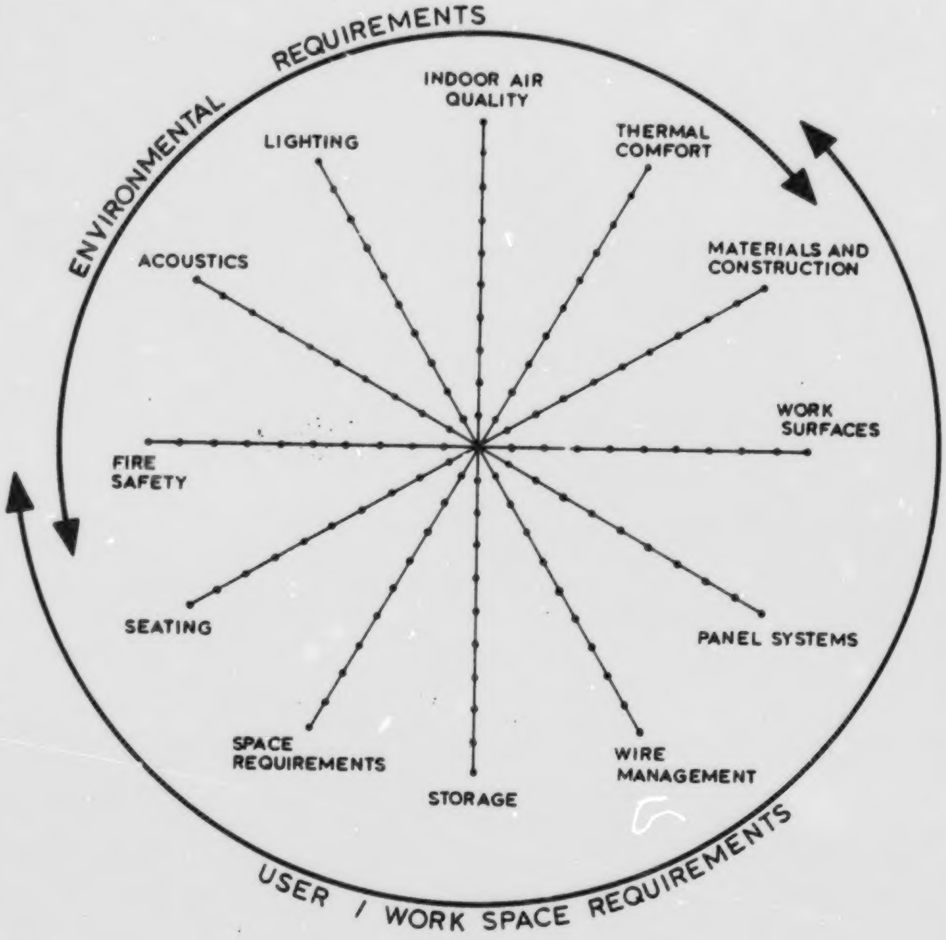
It is rather difficult to define desired performance at this level of consideration. In the Electronic Office Design Guide, each parameter (shown in Figure 2) is in turn treated in detail and the performance is defined at the most appropriate level to minimize ambiguity and optimize aspects of flexibility, especially for full-time operations involving multiple users.

Several methods of developing performance criteria exist (Table 2) and have been used, albeit intuitively, in the development of the performance requirements in the Electronic Office Design Guide. In essence, the process of developing performance specifications encompasses a functional analysis, formulation and evaluation of characteristics relating to "conditions-in-use" and the developing of evaluation methods (testing in the laboratory, calculations, expert judgement or subjective informed judgement).

Experience has shown that it is seldom necessary to state only a single value for each functional requirement; especially for documents like the Design Guide, where performance statements tend to become normative, and single value statements will correspond only poorly to the complex conditions met with in the daily office operations.

For the Electronic Office Design Guide, banded levels of performance have been specified in a number of instances because the documents would be applicable to a multitude of different and unknown projects and users. Consultants and designers working on specifications may sometimes know quite definitely which specific performance value they want or need for a given situation. Providing banded levels of performance permits the designer to make some trade-offs between cost and performance, and it also makes it possible for

FIGURE 2


ENVIRONMENTAL REQUIREMENTS
INDOOR AIR QUALITY
THERMAL COMFORT
MATERIALS AND CONSTRUCTION
WORK SURFACES
PANEL SYSTEMS
WIRE MANAGEMENT
STORAGE
SPACE REQUIREMENTS
SEATING
FIRE SAFETY
ACOUSTICS
LIGHTING
USER / WORK SPACE REQUIREMENTS

PERFORMANCE PARAMETERS FOR ANALYSIS AND EVALUATION OF ELECTRONIC OFFICES - MULTI-OBJECTIVE AND SYSTEMIC

users to select from several performance values. As decision methods evolve and trade-offs become more acceptable in evaluation of bids, manufacturers will be able to present products at various levels of performance (attribute profiles) - and, presumably, at various levels of cost.

In the Electronic Office Design Guide, each of the performance parameters is studied as a subsystem in relation to the electronic office as a system in order to provide a background for the performance statements and criteria (or banded level of performance) which are specified. A representation of the performance criteria (normalized to a scale of 10 for graphical purposes) is shown in Figure 3. This performance profile (acceptance profile) states in a *symbolic manner only* the minimum acceptable performance level on each and every requirement of the electronic office, and the profile would vary according to needs dictated by specific conditions.

One of the main difficulties to be surmounted in developing and using the performance concept embodied in the Electronic Office Design Guide stems from the limitations of the scales of measurements (nominal, ordinal or interval). These limitations relate to:

- the accuracy of the evaluation method;
- value judgements with respect to a specific performance requirement;
- value judgements with respect to priority (preference or importance between specific requirements).

In the Electronic Office Design Guide, only the minimum acceptable level(s) of performance (performance criteria) has been given (Figure 3). The performance profile, comprising the criteria from all the performance requirements, provides a method for direct comparison of proposed or existing electronic offices with the set of criteria on a pass/fail, yes/no, meet/does not meet basis. It is an ideal sought for its simplicity and objectivity (hence attractive for public tenders) and provides a basis for procedures which can be applied uniformly.

A very real dilemma arises with the use of performance specifications while deliberately setting out to promote innovation. Either the document is kept brief by requiring that only the most important performance criteria be met and risk accepting a design or product with a potential fault or else every eventuality must be covered to avoid the accusation of negligence. In the Electronic Office Design Guide, the emphasis has been on the development of a thorough, comprehensive, systematic set of performance requirements.

The criteria and test methods required for determining performance attributes of design proposals or products have been generally developed from nationally and internationally accepted practice and standards.

TABLE 2

METHODS OF SELECTING PERFORMANCE CRITERIA

METHOD	ACTIVITY	ADVANTAGES	PROBLEMS	APPLICABILITY
1. Subjective selection	-intuitive selection of a set of criteria or -systematic listing of criteria followed by	-not resource intensive -good results with 'right' expert(s)	-no direct user involvement -takes into account only one person's experience -justification of selection often not documented	-applicable only to problem areas where experts are available
a) by an individual expert	-selection based on the individual's knowledge and judgement		-difficulty of selecting expert (subjective)	
b) by a group	-selection based on group's knowledge, discussion and consensus	-based on several expert's experience		
2. Selection based on the availability of test methods	-Review of existing test methods, and selection among these by an expert or group of experts	-easy to evaluate (methods available) -easy to set levels (quantify) -moderately resource intensive	-no direct user involvement -problems of validity -methods often based on existing products (not innovative) -acknowledged lack of test methods in many fields	-a pragmatic way of selecting criteria, often used in performance specifying -applicable only to well established problem areas
3. Selection based on functional analysis	-definition of the main function of a product and subdivision of this into subfunctions, leads finally to a list of criteria related to the function, and to selection among these (or to various other/methods, eg. 1 or 2)	-aid in structuring available knowledge -use oriented -helps to identify gaps in knowledge -easy to use/not resource intensive	-no direct user involvement -presupposes a certain type of product -does not provide any new information -subjective selection often used	-often used in product development to create ideas to improve existing products. A structuring aid in performance work
4. Selection based on feedback from products in use	-collection and analysis of experience and problems with products in use	-user may be directly involved	-based on existing products (not innovative)	-often the basis for existing norms
a) complaints and records of failures	-collection of negative experience and problems only	-inadequate products may be eliminated	-defines negative not positive characteristics -time lag before problems are identified	-not recommended for developing performance specifications
b) surveys of products in use	-collection representative experience (positive and negative) -may use functional analysis as a framework (eg. for a questionnaire) -may lead to recognition of need for user studies	-both positive and negative characteristics are identified -it may be possible to determine the order of importance of attributes to the users -may identify redundant attributes	-may need to wait for a period of familiarization with the product before results are representative	-can be used to validate and develop a functional analysis and aid performance work
5. Selection based on the study of user requirements (research carried out at the time of selection)	-direct user participation in product specification, or -systematic research studies of user requirements and transformation of these into criteria	-user directly involved -gives the basic criteria against which to evaluate performance related to use	-often resource intensive (getting in touch with the user, etc.) -methodological problems -transformation to more technical language generally needed	-generally the task of research; needed when established information base not available

SOURCE: CIB WORKING COMMISSION W60 THE PERFORMANCE CONCEPT IN BUILDING "SETTING PERFORMANCE CRITERIA FOR BUILDING PRODUCTS", 1977

Where these are not available or do not adequately cover the specific aspect of electronic offices, deemed important, the criteria and test methods have been developed through studies and investigations in consultation with experts.

In developing the performance requirements, all the experts took into consideration that the Design Guide would represent the prototype Electronic Office in all aspects but the physically built form. With that in mind, graphical aids to interpretation of the design requirements have been used generously throughout the Guide. To make the document more useful still, a comprehensive checklist has also been developed.

4. ON THE USES OF THE ELECTRONIC OFFICE DESIGN GUIDE

The Design Guide was initiated in Alberta Public Works, Supply and Services in an effort to understand and come to terms with the multiple objective nature of electronic office planning in a comprehensive manner. It soon became obvious that the exercise had uses well beyond this initial purpose as:

- an aid to informed choice;
- an aid to innovation;
- a basis for future legislation;
- a basis for standardization within government organizations.

In developing the design guide, a number of target groups were identified:

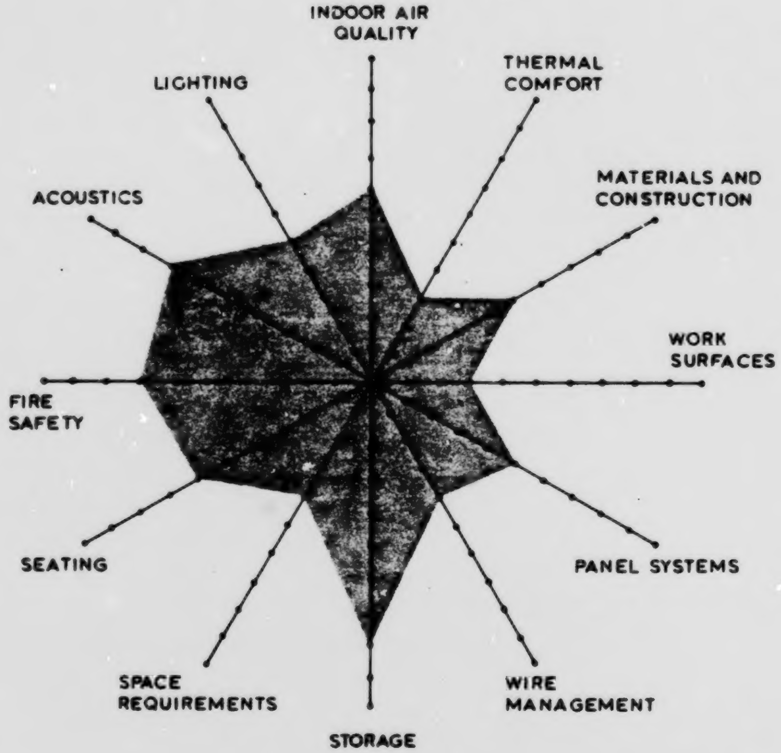
- Users/Clients (Electronic Office workers) to assist in programming input and as a basis for evaluating existing facilities
- Designers (Architects, Engineers, Programmers, Interior Designers and Specification Writers)
- Manufacturers/Industrial Designers.

These different groups require different approaches. The users and clients are not expected to understand the technical terms which designers and manufacturers find as second nature and so the document has been structured into two main parts:

- a detailed checklist of aspects to be considered;
- performance requirements and recommendations with supporting documentation.

The checklist prods questions in a general way only and it works as an aid to memory. It seems to be a useful tool for clients and users, especially in the programming stage, where it is easy to state performance requirements qualitatively but difficult to indicate methods of verification.

FIGURE 3



DEFINITION OF CRITERIA FOR ACCEPTABLE ALTERNATIVES
IN EVALUATION OF ELECTRONIC OFFICE

The performance requirements comprise both qualitative statements and quantitative criteria or banded levels of criteria. These performance requirements are suggested as guidelines for designers, manufacturers, users etc... In developing performance specifications for contract documents which are and should always be specific to a project, the values chosen should relate specifically to requirements of that project. It is at this level that the manufacturers' (suppliers' or contractors') performance declarations can be requested - and, hence, form a basis for evaluation.

In the Electronic Office Design Guide, an attempt has been made to respond directly to the needs and requirements of the office workers. It provides a basis for communicating, in broad terms, the requirements to industry (design and manufacturing) through precise, quantified criteria or banded level of criteria which can become the basis for industrial standards and for further refinement and development of performance based standards. In communicating specific requirements to manufacturers, the industry is given the freedom to innovate, limited only by the requirement that it provide the specified performance.

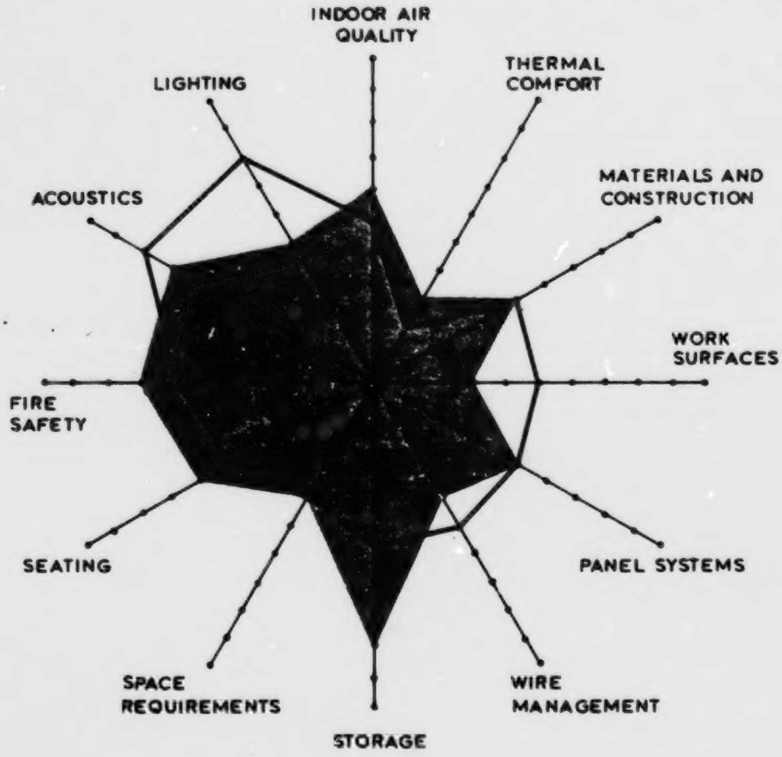
5. DESIGNING THE ELECTRONIC OFFICE

The modelling of design decision-making processes is fraught with difficulties. Notwithstanding these, most descriptions of the activities involved in design recognize a basic pattern. Design comprises a sequence of decisions leading from relatively abstract terms to the final specification of hardware.(7) The differences between methods reflect the variations in design problems and also variations in the operating mode of individual designers.

Analysis	Synthesis	Evaluation
Gathering Information	Creative Imaginative Integrative Techniques	Systematic
Defining Objectives		Appraisal, measurement
Structuring problems		Decision Techniques

In the design of electronic offices, a need for office space to house electronic equipment (VDTs, printers, etc...) is recognized. In tenant improvements or in the design of a new facility, the designer's first task is to understand, structure and state the design problem. This analysis phase comprises the gathering of relevant information, the definition of constraints and objectives and, where feasible, the definition of relationships between objectives.

FIGURE 4



COMPARISON OF ATTRIBUTES OF ALTERNATIVE SYSTEM VERSUS ACCEPTABLE CRITERIA FOR ELECTRONIC OFFICE FURNISHING SYSTEMS

SYSTEM DOES NOT MEET ALL CRITERIA - HENCE UNACCEPTABLE

Another important aspect of the Electronic Office Design Guide which spurred its development is that it allows for the impartial selection of furnishings and design proposals based on performance and not on pre-selected product alternates. In this connection, the design guide could be applied at different stages of the electronic office procurement process:

a. Preliminary scanning of the market;

b. Preparation of detailed specification;

c. Tendering and evaluation of bids;

d. Verification/User satisfaction.

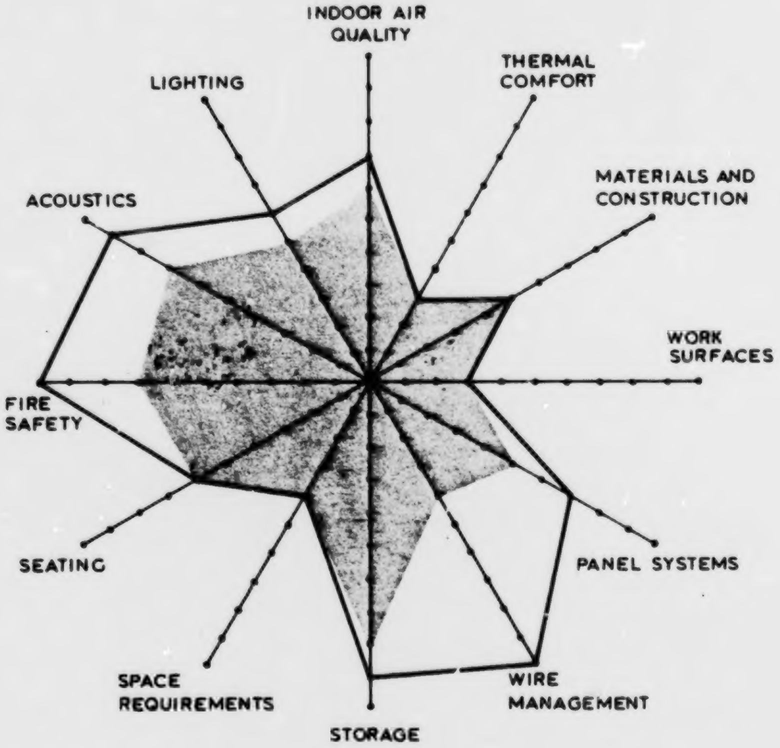
Because the government is seen to be a "continuous" client in the sense that the procurement activity goes on year after year - thus creating a continuous market - the possibilities created by applying the design guide in practice will be tempting for manufacturers to develop products which can live up to the performance desired because once a solution has been accepted, it can be manufactured for an assured and continuous market.

In programming and the early stages of design, there are substantial difficulties arising from the fact that the different users of the electronic office (systems analysts, programmers, data entry typists etc.) have different interests and expectations. During the early phases of a design, it may not be obvious what the performance requirements are, nor what the criteria should be. In the Design Guide, the checklist (in the form of questions to be asked by the users and designers) has been developed to solicit information for each aspect of the electronic office.

Using the Design Guide, the designer can establish a detailed set of performance requirements and criteria. The criteria given in the Design Guide correspond to the least acceptable value of performance requirement. It is recommended that these values be not lowered although a designer may trade off limits on less important requirements to achieve better performance on other more important requirements as dictated by the design context. (The definition of upper limits of performance objectives may be developed more fully in subsequent editions of the Design Guide. This should parallel developments in procurement policy and procedures in the government organization.) It must be stressed that the Design Guide is not a substitute for the programmer's or designer's role of identifying performance variables and the definition of the limits of acceptability. By developing the Design Guide, the designer of electronic offices is assisted in the systematic, explicit and conscious exercise of judgement, and consequences of decision changes can be studied.

The use of the checklist and Design Guide by the workers to provide an early input into the design process is also in the spirit of recommendations by the Canadian Labour Congress that "where new technology is being designed, introduced, proposed or already exists, workers must have real and meaningful input into the decision-making process from the very beginning".(8)

FIGURE 5



COMPARISON OF ATTRIBUTES OF ALTERNATIVE SYSTEM VERSUS ACCEPTABLE CRITERIA FOR ELECTRONIC OFFICE FURNISHING SYSTEMS

SYSTEM MEETS ALL CRITERIA I.E. SATISFICES - HENCE ACCEPTABLE

In order to achieve the objectives, a designer generates a number of feasible and admissible alternatives from which to choose. This synthesis stage - largely imaginative, dependent more on lateral rather than vertical modes of thought - is widely believed to be personal to each individual designer. A variety of processes - rational, intuitive, ordered or random may be appropriate to aid the synthesis of different solutions by different personalities.

Each of the alternative solutions proposed in the synthesis stage must be analyzed or tested in order to obtain estimates of how each solution will perform relative to the criteria and constraints defined in the performance specifications (Figures 4 and 5). The evaluation activity compares the output of analysis or test with the specifications in order to obtain an estimate of the worth of each solution to the design problem. The decision activity involves answering questions such as:

a. Which of the proposed design solutions best meets the performance requirements of the electronic office (in context)?

b. Is the best solution good enough to justify proceeding to the next stage (i.e. procuring furnishings)? or should any or all the activities of the design process be repeated?

c. Is the Electronic Office Design Guide adequate or should it be developed further?

Complicating the process of design decision-making is the fact that alternative solutions to the specific electronic office design problem inherently possess the following characteristics:

- The alternatives are multi-attributed; hence the problems of multi-criteria decision-making;
- There is no unique measure of an alternative's worth from the performance attributes of the system (evaluation, transformation, weighting, etc...);
- The attributes associated with a proposed solution cannot be known with certainty nor, in some instances, do they relate directly to performance requirements (Need for informed judgement? More tests?)

The design decision-making activity is not uni-directional. It is recognized that progress towards achievement of an optimal design solution may require repetition of prior activities; strong feed-back loops may and do occur throughout the design process.

6. ELECTRONIC OFFICES - PROCUREMENT CONSIDERATIONS

Procurement for a project has been defined in broad terms as "the basic commercial process of the securing and delivering the required goods and services to a project".[(9)] The implementation of the procurement process starts with the formal identification and definition of requirements (contract documents), works through the process of finding it, committing to it, affecting its delivery to its point of application and the closing of the commitment obligations of the parties.(10) In its simplest terms, the procurement process consists of the following steps:

- Identification and definition of requirements
  - Performance specifications
  - Quantity
  - Timing
  - Cost
- Call for tender/competitive bidding
- Evaluation/clarification of bids
- Award of contract
- Administration of contract
- Final acceptance and close.

The information produced by the activities of the design process is generated in the form of contract documents (drawings and specifications) for the facility (new building or tenant improvements) and also for the furnishings, usually in separate, sequenced contracts.

The use of performance specifications in the call for tender is especially well suited to the procurement of furnishings of electronic offices where developments have been rapid. The most useful feature of the performance approach is that the specifications form the basis for an impartial evaluation of the furnishing systems, a quality which is not evident when the evaluation is based on pre-selected product alternates.

The use of performance specifications in the procurement of furnishings for electronic offices can be used either in the conventional public tender process or through the two-step formula (a process gaining wide recognition in the U.S.A.).

i. **Public Tender**
In the public tender process, the price criterion is the basis for deciding among competitive bids. It has the virtue of simplicity. It is seen as cutting out subjective judgement as much as possible. It is intended that the award of a contract is fair and equitable - no public favour is to be shown. For the public and within public organizations, the award of a contract to the lowest bidder has traditionally been seen as what constitutes accountability.

In a large number of cases, where information on other performance aspects is not readily available, the minimum price criterion is indeed justifiable, even desirable. However, competitive selection on the basis of bid price alone can mean inadequate allowance for judgements about quality and performance in the case of products and construction procurement. Once variations of consequence in products and construction are admitted, the original competitive basis of minimum cost is eroded - hence the need for multi-attribute decision-making.

To take the bid price as the sole criterion for selection is, at best, to avoid the task of achieving good value and an efficient product; at worst, it can be seriously negligent.

Efforts to achieve *value for money* - another concept of accountability - should not be hampered by procedures to eliminate the possibility of corruption. There is a need for wider acceptance of performance criteria in addition to a bid price as a basis for decision-making. This could only be brought about if performance criteria were specified and guidelines for applying them made explicit to all concerned. The criterion for eligibility of a furnishing system and, hence, a bid, would be compliance to each and every specification. (See Figures 2 to 5 for symbolic representation of the process) The objective function for the decision is still the lowest-priced bid or, more specifically, the lowest-priced *eligible* bid. In this manner the advantages of the competitive situation, firm price and public accountability have been maintained.

ii. **Two Step Formula:**
Essentially this approach formalizes and distinguishes the eligibility criterion from the decision process. Step One of this process - the Technical Proposal Phase - consists of the request for, and the submission, evaluation, and if necessary, discussion of *a technical proposal* without pricing to determine the acceptability of the furnishings offered. Upon completion of Step One, a formally advertised public tender is conducted, except that the Invitations for Bids will be issued only to, and considered only from, those eligible i.e. those whose Technical Proposals have been evaluated and determined to be acceptable previously.

7. MECHANISM FOR UPDATING THE ELECTRONIC OFFICE DESIGN GUIDE

It is evident that the value of the Electronic Office Design Guide lies primarily in the currency of the information, requirements and criteria. The need to update the document on a regular basis results from:

- Rapid developments in the electronic equipment industry
- Continuing intensive research in the ergonomics of the electronic office
- Developments and improvements in the furnishings manufacturing industry to meet the needs of the electronic office
- Evaluation and feedback of the Electronic Office Design Guide after it has been applied in projects.

The need to update this document begs the question "How often?" The frequency of update should be at least on a yearly basis to take into account the developments in the electronic equipment industry and also with the furnishings manufacturers. The next edition should be undertaken as soon as the initial reactions to the use of the design guide are given and every effort will be made at this stage to incorporate the performance requirements for seating.

The mechanism for updating the document can be problematic, for the design guide comprises graphical and textual material. For the written component, the word processor provides an easy way of storing the text and modifying it as necessary. With the graphical component, which is integral to the document, it is not as simple - developments in electronic equipment may, however, provide an inexpensive solution soon.

The various aspects of the Design Guide will be reviewed and revised by experts, (just as the Design Guide was developed by experts). Prior to each update, feedback from the users of the documents should actively be sought and so should information from manufacturers - both electronic equipment and furnishings.

8. IN CONCLUSION

The design of an electronic office is still more of an art than a science. There are more considerations than most people are aware of when the task is first begun, and the workstation and the environment are frequently given short shrift until the equipment is ordered, delivered and ready to be installed. The Electronic Office Design Guide provides a basis for a more systematic and comprehensive approach to the electronic office from the planning and programming stages through design and procurement to the acceptance and evaluation (post-occupancy or existing facilities) of electronic offices.

The problems in conventional offices (relating to space requirements, work surfaces, seating, thermal comfort, indoor air quality, wire management, lighting, acoustics, fire safety, materials and construction, storage, panel systems) are magnified in the electronic office. For those interested in solving the problems, or rather in meeting the challenge, of the electronic office the available documentation has been widely scattered and not easily available; it has often been difficult to define criteria and standards specifically related to electronic offices.

The Electronic Office Design Guide - in itself a model theoretical electronic workstation - provides a comprehensive and systematic definition of the requirements and forms the basis of solutions to problems of electronic offices. The problems are numerous, but not insoluble.

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ELECTRONIC OFFICE DESIGN GUIDE

ELECTRONIC OFFICES: Some Questions to Bear in Mind

The purpose of this checklist is to identify important aspects which the users, programmers, designers, specification writers, manufacturers and researchers must consider in relation to the electronic office. In using this checklist, it should be understood that there is no order of priority implied in the questions nor is the list sequential. The questions form part of the cyclical process in which all the participants in the design, construction and use of electronic offices give sufficient consideration to the right aspects at the appropriate time. Because of the different users of the checklist and Design Guide, each with their different purposes, there are in reality as many checklists as there are user types. No effort has been made to relate the checklists to the users; the sections are as set out in the Electronic Office Design Guide.

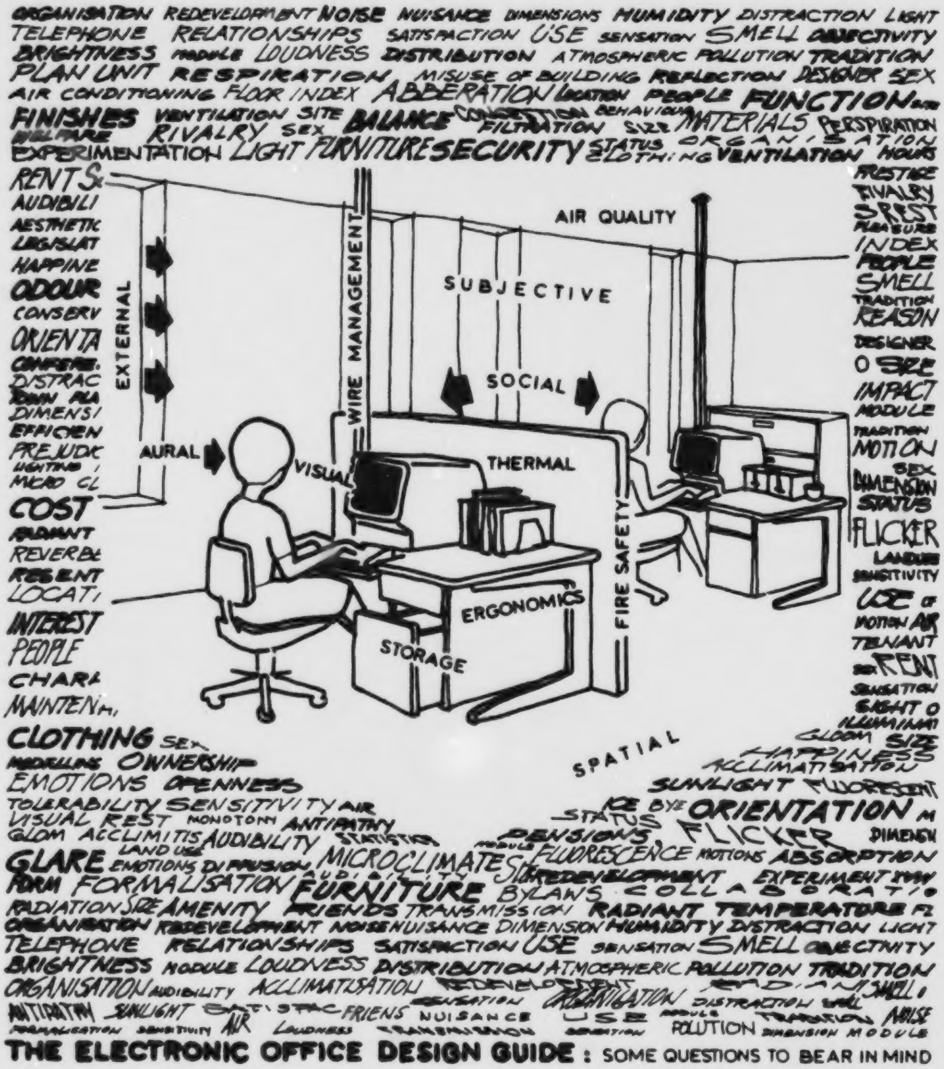
It is important to keep in mind the context of the Electronic Office:

i) The need for flexibility to accommodate change in the office space, distinguishing between the concept of the long life of the base building or shell and the much shorter life of the tenant improvements

ii) The changing trends in office space and relationship with organizational and operational developments; this being especially crucial in terms of the electronic office.

iii) The electronic office, all said and done, should provide an environment in which each individual can within reason create conditions which best fit his or her particular pattern of work.

Offices are highly complex and difficult to plan. This checklist and design guide for the electronic office do not deal with conference rooms, mail rooms, storage and filing etc... It has been the intention to produce a comprehensive briefing document not to provide for all aspects of the office in general but only the workstation and the electronic office environment in particular. Understanding and defining requirements of the physically disabled is desirable and would be a logical development of the design guide in future editions.


ORGANISATION REDEVELOPMENT NOISE NUISANCE DIMENSIONS HUMIDITY DISTRACTION LIGHT
TELEPHONE RELATIONSHIPS SATISFACTION USE SENSATION SMELL OBJECTIVITY
BRIGHTNESS MODULE LOUDNESS DISTRIBUTION ATMOSPHERIC POLLUTION TRADITION
PLAN UNIT RESPIRATION MISUSE OF BUILDING REFLECTION DESIGNER SEX
AIR CONDITIONING FLOOR INDEX ABBERATION LOCATION PEOPLE FUNCTION
FINISHES VENTILATION SITE BALANCE CONGESTION BEHAVIOUR FILTRATION SIZE MATERIALS PERSPIRATION
WELFARE RIVALRY SEX ORGANISATION
EXPERIMENTATION LIGHT FURNITURE SECURITY STATUS CLOTHING VENTILATION HOURS
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SOCIAL
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VISUAL
THERMAL
ERGONOMICS
FIRE SAFETY
STORAGE
SPATIAL
CLOTHING SEX
MODELLING OWNERSHIP
EMOTIONS OPENNESS
SUNLIGHT FLUORESCENT
TOLERABILITY SENSITIVITY AIR
VISUAL REST MONOTONY ANTIPATHY
STATUS ORIENTATION
GLOOM ACCLIMITIS AUDIBILITY STATISTICS
DIMENSIONS FLICKER DIMENSION
LAND USE
GLARE EMOTIONS DIFFUSION MICROCLIMATES MODULE FLUORESCENCE MOTIONS ABSORPTION
FORM FORMALISATION FURNITURE AUDIBILITY REDEVELOPMENT EXPERIMENT
BYLAWS COLLABORATIO
RADIATION SIZE AMENITY FRIENDS TRANSMISSION RADIANT TEMPERATURE
ORGANISATION REDEVELOPMENT NOISE NUISANCE DIMENSION HUMIDITY DISTRACTION LIGHT
TELEPHONE RELATIONSHIPS SATISFACTION USE SENSATION SMELL OBJECTIVITY
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ORGANISATION AUDIBILITY ACCLIMATISATION REDEVELOPMENT ORGANISATION RADIANT SMELL
ANTIPATHY SUNLIGHT STATISTICS FRIENS SENSATION NUISANCE USE DISTRACTION MODULE TRADITION NOISE
FORMALISATION SENSITIVITY AIR LOUDNESS TRANSMISSION SENSATION POLLUTION DIMENSION MODULE

THE ELECTRONIC OFFICE DESIGN GUIDE : SOME QUESTIONS TO BEAR IN MIND

1. SPACE REQUIREMENTS

1.1 Is the number of work stations provided sufficient?

1.2 Are the sizes of the work stations adequate to accommodate the electronic office equipment?

1.3 Does the workstation provide enough clearance for movement between work surfaces without obstruction?

1.4 Does the leg area permit unobstructed turning?

1.5 Are all items of equipment which must be manipulated manually within the easy and normal reach of the operator? ie, within reach without requiring movement or difficult contortions of the body?

1.6 Is the space provided for storage of copies, handbooks, documents, personal belongings, etc. adequate? accessible?

1.7 How flexible are the single user work stations? Multiple user workstations? What configurations are possible with one workstation? Several workstations? Can the components be arranged in various combinations in order to serve multiple users?

1.8 Is the floor area adequate for furnishings, circulation, equipment, storage, etc...? for single user/multiple user workstations?

2. WORK SURFACES

2.1 Do the work surfaces have a bias towards right or left handed use?

2.2 Do primary work surfaces provide adequate length? width? area? for VDTs and large format documents, reference etc.?

2.3 What range of primary work surfaces dimensions are needed? available? Secondary work surfaces?

2.4 How is the electronic equipment accommodated on the primary work surface?

2.5 What provision is made for adjustments? up and down movement? Vertical rotation (tilt)? VDT? Keyboard?

2.6 How will undesirable equipment movement be prevented?

2.7 Will the work surfaces be strong, continuous and serviceable under different service conditions?

2.8 How easily can the work surfaces be maintained? Repaired? Where? By Whom?

2.9 How stable and durable are the work surfaces?

2.10 Is the potential for static electricity reduced or removed by the material used as the work surface?

3. STORAGE

3.1 Is the storage capacity in the workstation adequate?

3.2 What types of storage units are available?

3.3 Are the storage units available as standard, modular components?

3.4 Are the storage units available as fixed and mobile units?

3.5 Are the storage units functional? What are they capable of storing? What type of binders can they accept?

3.6 Are the storage units within convenient reach?

3.7 What safety measures are embodied in the design to prevent accidental dislodging of shelves, cabinets, etc...?

3.8 Can the storage units be locked? How?

3.9 How can the mobile storage units be moved?

3.10 Do the shelves and other storage units have rounded edges?

3.11 How functional and durable are the drawer mechanisms and shelves?

4. PANELS

4.1 What types of panels are available?
- classified by form
- classified by finish
- classified by function.
- classified by colour and reflectance.

4.2 What can the panels accommodate?
- Work surfaces? what kind?
- Storage systems? What types?
- Wiring? how much? how?
- Lighting? What kind?
- Display systems?
- etc.?

4.3 How is the wire management integrated into the panel? Are the communication, data and power lines housed separately?

4.4 How are the panels to be used?
- For visual privacy? Are they adequate?
- For aural privacy? Are they adequate? How effective should they be?
- For spatial separation? How effective are they?
- What fire safety measures should be incorporated into their design and construction?

4.5 What are the critical dimensional requirements? Can these be met by the panel system?

4.6 Are the panels available in modular sizes? What is the module — vertical? horizontal?

4.7 What are the weights of the panels?

4.8 How stable is one free-standing panel?

4.9 How stable is a configuration of panels?

4.10 What is the dimensional stability of a panel subjected to long term humidity and temperature variations?

4.11 How can the finishes be maintained? repaired? replaced?

4.12 What are the alignment limitations for construction of workspaces? for long term use?

4.13 What measures have been taken to ensure that a configuration of panels does not collapse from regular use?

4.14 When work surfaces and equipment are cantilevered from panels, what are the maximum loads which can be attached? What is the deflection ?

4.15 How is the panel supported? Do the supports protrude excessively beyond the panel? How much?

4.16 How can the panels be transported? Can the supports be removed or retracted?

4.17 What measures are taken to minimize damage to the floor surface by the panel supports?

4.18 How can the panels or panel configurations be moved on a floor without damage to the floor?

4.19 How does the panel system accommodate variations in the floor surface? What is the maximum variation that can be taken up by the panel systems?

4.20 What tools are needed to connect panels? to adjust levels? etc...

4.21 How easy is it to install the panels? Are specialists required?

4.22 Are parts available? What type and quantity are needed?

4.23 What configuration of panel types can be connected?
- different heights of panels?
- different angles between panels?

4.24 Will the use of panels reduce the illuminance on the work surface to below the recommended level?

4.25 What will be the impact of the panel system/workstation configuration on air movement?

5. SEATING

5.1 Is the chair intended to support a clerical/secretarial function? Data entry and processing work? Or supervisory/management tasks?

5.2 Does the chair adopt to the functions of the task?

5.3 Does the chair adjust to the anatomy of user?

5.4 Is the support achieved through proper seat and back contouring and internal construction materials?

5.5 Does the seating design enhance proper posture? Reduce stress on the back and leg muscles? Assure even pressure on the spinal discs?

5.6 Is the seat angle sloped? How much? How? Is it adjustable?

5.7 Are the front edges radiused to relieve excessive pressure on the thighs? Do they allow the lumbar region to relax into a concave position? Do they prevent undercutting behind the knees?

5.8 How is the seat contoured? Does it contribute to the distribution of body weight? Does it provide lateral thigh and back support? Does the contouring prevent rotation of the pelvis as the occupant swivels in the chair.

5.9 How does the back rest maintain the correct spine curvature in the lower lumber region? Does it avoid the shoulder blades? Is it adjustable in height, angle and tension?

5.10 Is the seat height adjustable? easily? how?

5.11 Can the chair be maneuvered? Smoothly? Are the casters appropriate to the flooring material? How durable are they?

5.12 How stable is the chair? What is the configuration of the prongs?

5.13 Are arm rests required? desired? Are the arm rests upholstered?

5.14 What type of fabric is used on the chair? How durable is it? Is it coarse? itchy? Can it be cleaned easily?

6. WIRE MANAGEMENT

6.1 Is the wire management system in accordance with CSA Standard? the Canadian Electrical Code? Provincial regulations? local inspection requirements? APWSS Department Standards?

6.2 Is the wiring when installed, concealed? safely mounted? flexible?

6.3 Are the panels capable of accepting pre-manufactured electrical components or standard electrical components which can be fitted in the field to provide electricity, telephone and communications to the work station as required?

6.4 Who supplies the wire management system? How is the system installation to be coordinated with base building wiring? Are base building wiring systems adequate?

6.5 Are separate wireways provided in the panels? How many are provided?

6.6 How can the wire management system accommodate joints between panels? two-way panels? three-way panels? What about configuration angles?

6.7 What space is available in the panel system to allow access to wiring outlets? What type of outlet connections are they? How do they affect the available cross-sectional area?

6.8 How is the feed from the base building to the panel effected? How large are the wireways?

6.9 How is access provided to the wireways? Are the face plates removable? Do they have cut-outs in lieu of standard cover plates?

6.10 Are special trades people required to install the wire management systems?

6.11 Are electrical components interchangeable? Can panels be retrofitted with these components to accommodate change in the office? Can the panel system accept standard wiring components?

6.12 How many computer grade circuits are available in a workstation? How can these circuits be differentiated from regular circuits?

6.13 Are there any provisions to avoid static electricity interference in a workstation?

6.14 Is wiring for task lighting necessary? provided?

6.15 Are the wiring systems colour coded? How?

7. MATERIALS AND CONSTRUCTION

7.1 Do the materials and construction appear to be sufficiently durable to withstand wear imposed by normal tasks?

7.2 Is the workstation "Knock-Down"construction? easily transportable?

7.3 What are the tolerance levels of the component?

7.4 Of what are the components made? Are the components sturdy? Will they shake or vibrate from moderate impact? Will they yield to pressure?

7.5 How rigid is the construction? How functional? How strong? how durable?

7.6 Will the hardware endure constant use and is it firmly fixed? How are the components fastened?

7.7 Is the construction sufficiently strong to support the weight of persons? machines? etc...?

7.8 Are finishes free from roughness which might cause injury to persons or clothing? Are there sharp edges, corners or potentially injurious protrusions?

7.9 Does the overall appearance provide a pleasant working environment?

8. LIGHTING

8.1 General

8.1.1 Does the design and use of VDT equipment and work places have to meet the requirements of guidelines or legislation? Which ones?

8.1.2 How frequently are the eyes of the operators tested? Is the eye doctor informed that it is the eyes of a VDT operator which are being tested?

8.1.3 How difficult is the visual task?

8.1.4 Do the source documents have clear, easy to read, characters?

8.2 Displays

8.2.1 Is the minimum character size 3.0 mm or 18 minutes of arc?

8.2.2 Are the characters upright, sharp, well-defined and unamibiguous?

8.2.3 Do the characters retain their identity when their luminance is varied?

8.2.4 Are both upper case and lower case characters in the display?

8.2.5 Do the descenders of the lower case characters project below the base line of the matrix?

8.2.6 Are the characters generated by a 7 x 9 or greater matrix of individual dots?

8.2.7 Is the character width, the stroke width, the space between the characters and the space between the rows to the specified dimension?

8.2.8 Does the display have an easily distinguished cursor? Can the blink action of the cursor be suppressed?

8.2.9 Is the display big enough for the information required by the operator?

8.2.10 Has the selection of the colour of the characters been a matter of personal choice?

8.2.11 Can the luminances of the characters and the background be varied by the operator?

8.2.12 Has consideration been given to the use of colour or luminance coding in the display? Has this taken into account the number of colours and the number of luminances to be distinguished?

8.2.13 Is a positive contrast screen (with light characters on a dark background) to be preferred to a negative contrast screen (with dark characters on a light background)?

8.2.14 Are the characters steady or do they appear to flicker?

8.3 Reflectances and finishes of principal surfaces in space containing VDTs.

8.3.1 Are drapes of specified reflectance over the windows? Are venetian blinds so located that they are likely to create bands of light and dark on the screen?

8.3.2 Do the principal surfaces (walls, ceiling, etc.) of the VDT work space have non-glossy finishes of the specified reflectances?

8.3.3. Do the keys have a matt finish of medium to high reflectance with bold, black characters?

8.4 Illuminance (Light Level)

8.4.1 Is the minimum ambient lighting 300 - 500 lux (30-50 footcandles) in the work space? Is the minimum task lighting 600-800 lux (60-80 footcandles)?

8.4.2 Can the illuminance on the work be increased by local lighting? Is it necessary?

8.5 Lighting systems

8.5.1 Is the general illuminance produced either by a direct lighting system with low luminance luminaires or by an indirect lighting system or by a combination of these systems?

8.5.2 Is the luminance of the low luminance luminaire within the specified limits?

8.5.3 Are the low luminance luminaires located at the sides of the workstation and parallel to the line of sight of the VDT operator? (Not always possible in open plan offices)

8.5.4 Are the ceiling luminances produced by the indirect lighting system within the specified limits and without sharp changes in luminance?

8.5.5. Are the walls comfortably bright?

8.6 Lamps
Does the lighting system use lamps having the specified minimum General Colour Rendering Index (R_a)?

8.7 Location of VDT Operator
Are the VDTs so located that the operators see neither bright sources nor reflections in the screen of those sources? The bright sources may be luminaires or windows, other light coloured furniture, filing cabinets, pictures, clothing.

8.8 VDT Operation

8.8.1 Is the centre of the screen slightly below eye level?

8.8.2 Can the screen be tilted and rotated?

8.8.3 Can a visor be fitted to the screen?

8.8.4 Is it necessary to have a filter over the screen?

8.9 Maintenance
Are the luminaires and VDT screen kept clean?

9. ACOUSTICS

9.1 What level of speech privacy is required?

9.1.1 What is the level of the "voice effort" of the people talking?

9.1.2 What is the reduction in sound level between workstations?

9.1.3 What is the level of the ambient noise.

9.2 How effective are the screen characteristics in reducing sound transmitted from one workstation to another?

9.2.1 Sound Transmission Class?

9.2.2 Height of screen?

9.2.3 Noise Reduction Coefficient?

9.3 How effective is the ceiling in reducing sound reflection from one workstation to another?

9.3.1 What is the Noise Reduction Coefficient of ceiling panels?

9.3.2. What is the proportion of luminaires to total ceiling surface area? What type of lenses are used on the luminaires? What is the effect of the luminaires on the sound reflection by the ceiling?

9.4 How effective is the ceiling in reducing the transmission loss from one workstation to another?

9.4.1 Sound Absorption?

9.4.2 Sound Transmission Class?

9.5 How effective is the layout in providing speech privacy?

9.5.1 Are sight lines between office workers avoided?

9.5.2 What is the minimum separation between people?

9.5.3 What is the working position of the electronic office workers? side by side? back to back? facing each other?

9.5.4 How far are the workers from sound absorptive surfaces?

9.5.5 How far are the screens from walls, windows, columns, etc...?

9.5.6 Are noisy operations adjacent to quiet areas?

10. THERMAL ENVIRONMENT

10.1 Do the environmental parameters produce conditions of thermal comfort for the occupants?

10.1.1 Temperature?

10.1.2 Humidity?

10.1.3 Thermal Radiation?

10.1.4 Air movement?

10.2 What are the personal parameters to be considered?

  10.2.1 Clothing?

  10.2.2 Activity?

10.3 What is the temperature in the workstation? What are the optimum comfort temperatures in the office?

  10.3.1 In Winter?

  10.3.2 In Summer?

10.4 What is the humidity in the workstation? What are the limits on humidity for the thermal comfort range in the electronic office?

10.5 What is the air movement in the workstation? What is the range of acceptable air movement for achieving thermal comfort in the electronic office?

  10.5.1 In Winter?

  10.5.2 In Summer?

10.6 What is the mean radiant temperature in the workstation? Any local heating effects from the VDTs?

10.7 Does the temperature in the workstation cycle during occupancy? To what extent?

10.8 Does the temperature vary during the day? How much?

10.9 What is the vertical temperature difference in the work station?

10.10 Is the workstation subject to radiant asymmetry? In what direction?

10.11 What is the activity level in the workstation? How does it vary? Does it affect thermal comfort conditions?

11. INDOOR AIR QUALITY

11.1 What is the occupancy of the workstation? of the office space?
- Numbers?
- Density
- Activity Level?

11.2 What are the sources of contamination in the office?
- smoking
- furnishings
- special processes

11.2.1 What is the contamination level in the workspace?

11.2.2 What types of contaminants are present?

11.2.3 How are these contaminants treated?

11.3 Is the workspace mechanically vented? mechanically cooled?

11.3.1 What types of air cleaning devices are used?

11.3.2 What is the efficiency of air cleaning devices?

11.3.3 How is humidity provided?

11.4 Is the ventilation air uniformly mixed in the occupied space?

11.5 Is the indoor air quality acceptable at all times, even when the supply of air is reduced while the space is occupied?

11.6 Where are the make-up air inlets located? exhaust air outlets? Is the make up air from clean air supply?

12. FIRE SAFETY

12.1 What is the fire load in the electronic office?

12.2 Do the furnishings burn? How do the furnishings perform in the development of a fire?
- incipient stage?
- developing stage?
- fully developed stage?

12.2.1 Do the furnishings meet regulations with respect to:
- control of ignition resistance?
- control of fire growth after ignition? flame spread? heat release?
- Limiting contribution to fully developed fire? fuel load? heat release? Release of nasty vapors?

12.3 Are waste containers used in the office fire-restraining?

12.4 Is the office space sprinklered?

12.5 Are smoke and heat alarms installed?

12.6 Can the heating and ventilation systems isolate smoke and heat?

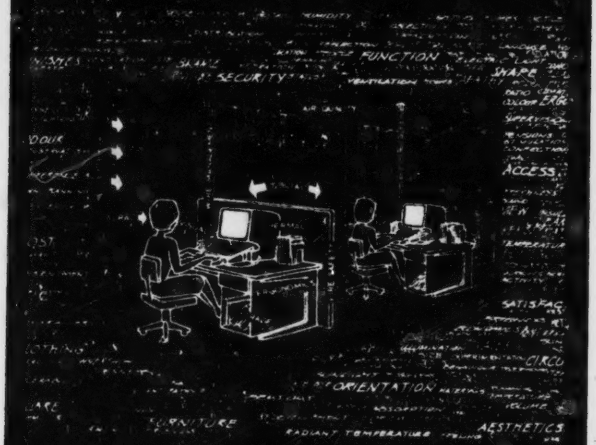
12.7 What provisions have been made for escape?
- distance to fire exit?
- signage?
- panic hardware?

12.8 What are the fire safety educational programs in use?

12.9 How toxic is the smoke generated during the fire? How much smoke is developed during a fire?

12.10 What is the fire classification of the upholstery fabric?

ELECTRONIC OFFICE DESIGN GUIDE


HUMIDITY
FUNCTION
SECURITY
VENTILATION
SHAPE
AIR QUALITY
ODOUR
ACCESS
COST
TEMPERATURE
SATISFAC
CIRCU
ORIENTATION
VOLUME
ABSORPTION
FURNITURE
AESTHETICS
RADIANT TEMPERATURE

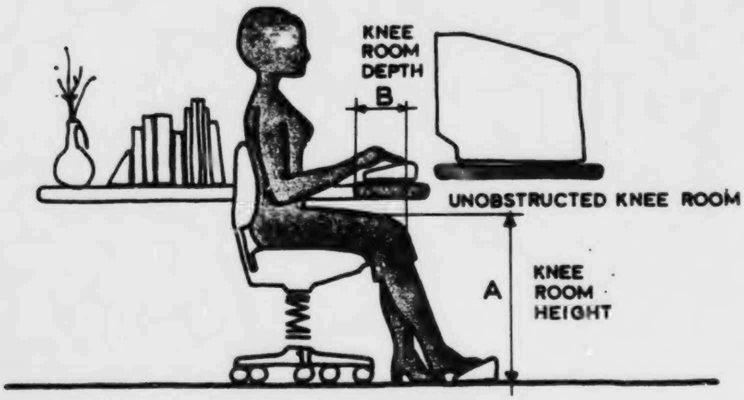
SPACE REQUIREMENTS

INTRODUCTION

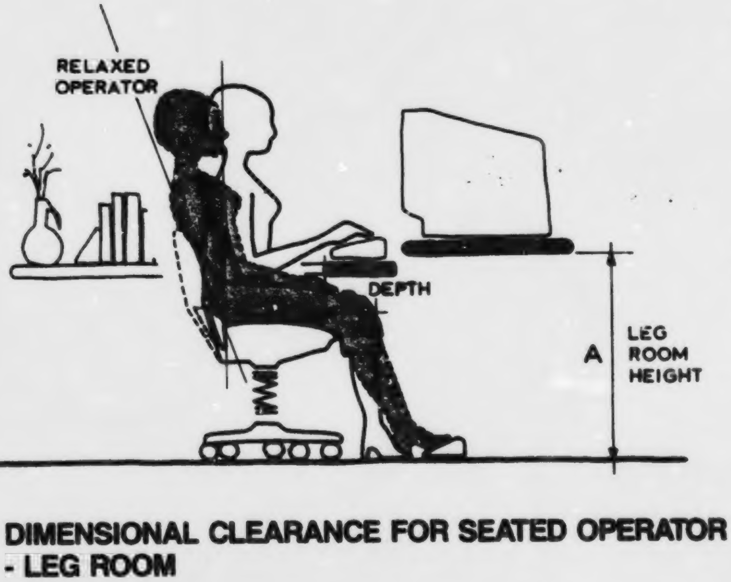
Electronic office equipment has been introduced to the open office plan with little consideration for its unique dimensional, functional and ergonomic differences. VDTs, keyboards, word processors and printers all consume valuable work space substantially more than the traditional typewriter - and as a result will directly affect work-space requirements. Worker's needs for acoustic and visual privacy, intra-office communications and the environmental conditions of the office space must also be considered to arrive at a comprehensive yet economic solution.

The allocation of space and furnishings on the basis of a user's position within the organization's hierarchy cannot be planned with any accuracy because of the variety of work space conditions within the modern office. To achieve a harmonious balance, space requirements must be based on the work activities and inventory of equipment anticipated in the work space. Once determined, work surfaces, storage systems, lighting and acoustic controls can be assigned and workstation space requirements determined.

The performance requirements stated in this section are based on a systematic analysis and evaluation of space needed for the execution of the varied tasks, circulation, storage and accommodation of the equipment.


KNEE
ROOM
DEPTH
B
UNOBSTRUCTED KNEE ROOM
A
KNEE
ROOM
HEIGHT

1.0 DIMENSIONAL CLEARANCE FOR SEATED OPERATOR - KNEE ROOM


RELAXED
OPERATOR
DEPTH
A
LEG
ROOM
HEIGHT

2.0 DIMENSIONAL CLEARANCE FOR SEATED OPERATOR - LEG ROOM

GENERAL REQUIREMENTS

1.0 The workstation shall provide adequate knee room for clearance when seated, at all work spaces, and shall not inhibit movement between perpendicular and adjacent work surfaces.

CRITERIA: Movement without obstruction between perpendicular surfaces.

Knee room height: A = 660mm - 780mm

Knee room depths: B = 400mm - 550mm

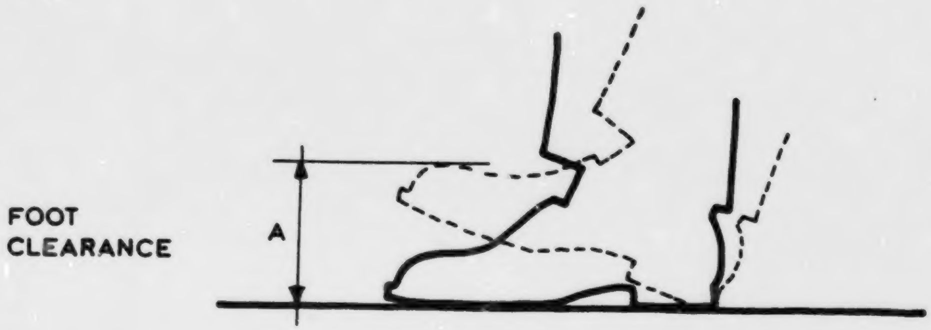
(PRODUCT MEASUREMENT)

2.0 The workstation shall provide adequate leg room clearance at all work surfaces for seated operator.

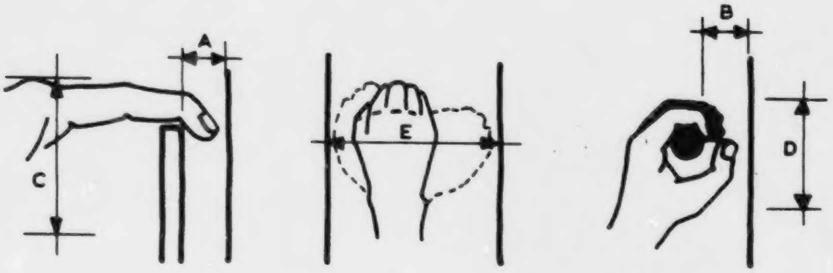
CRITERIA: Leg room height: A = 660mm - 762mm

Leg room depth: B = 600mm - 700mm

(PRODUCT MEASUREMENT)


FOOT
CLEARANCE
A

3.0 DIMENSIONAL CLEARANCE FOR SEATED OPERATOR - FOOT CLEARANCE



4.0 DIMENSIONAL CLEARANCE FOR HANDS AND FINGERS

3.0 The workstation shall provide adequate foot clearance for a seated operator.

CRITERION:

Foot clearance height: A = 160mm - 300mm

(PRODUCT MEASUREMENT)

4.0 All hand controls, drawer pulls, handles, knobs, etc., shall provide adequate space for hands and fingers.

CRITERIA:

Finger tip clearance: A = 25mm - 35mm

Finger grip clearance: B = 25mm - 35mm

Hand depth clearance: C = 50mm - 70mm

Hand grip clearance: D = 110mm - 120mm

Hand rotary clearance: C = 120mm - 140mm

(PRODUCT MEASUREMENT)

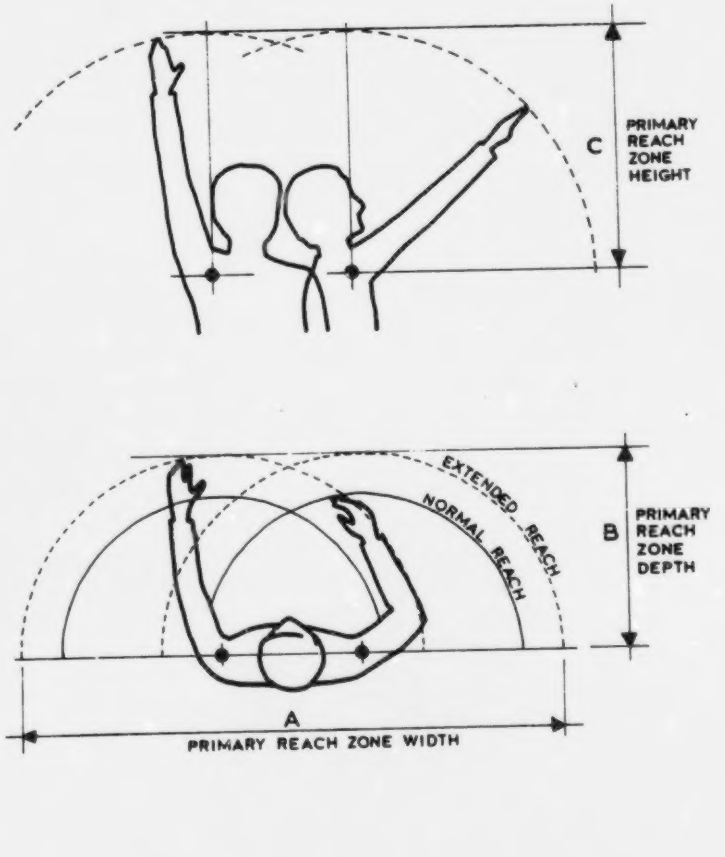
5.0 Frequently used hand controls shall be within easy reach, in the primary reach zone of the operator.

CRITERIA: Primary reach zone width: A = less than 1500mm

Primary reach zone depth: B = less than 600mm

Primary reach zone height: C = less than 800mm

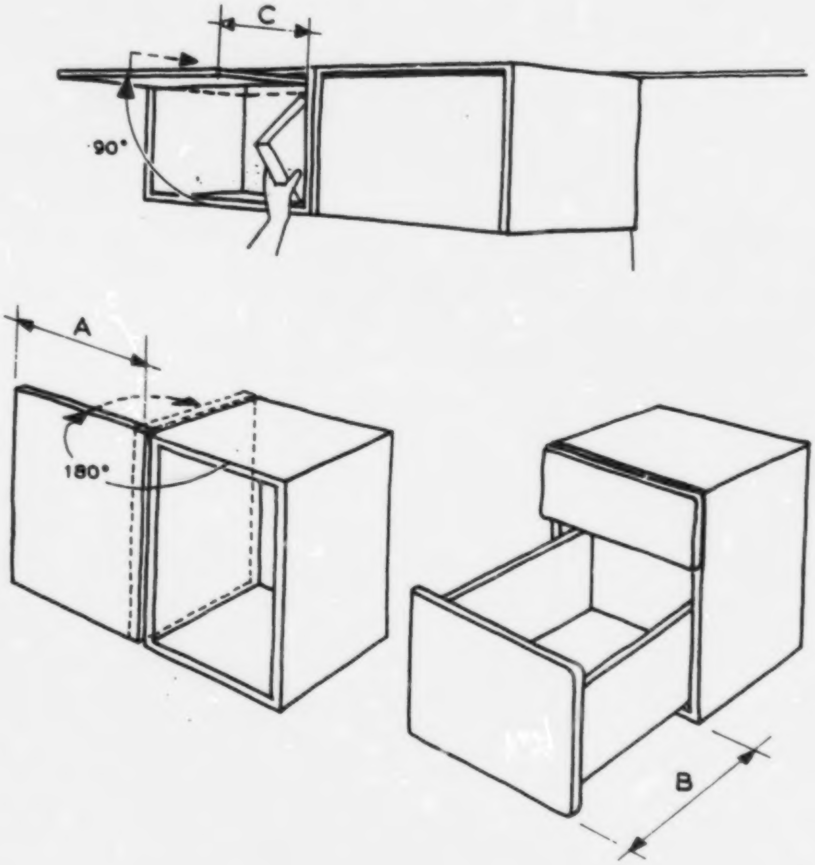
(PRODUCT MEASUREMENT)


C
PRIMARY REACH ZONE HEIGHT
EXTENDED REACH
NORMAL REACH
B
PRIMARY REACH ZONE DEPTH
A
PRIMARY REACH ZONE WIDTH

6.0 All storage units shall be designed with closures which minimally intrude into work activity and circulation zones. The minimum rotation permitted by the hinges and construction should be 180°.

For the common storage closures shown A, B and C should be selected to minimize intrusion into work space and circulation zones.

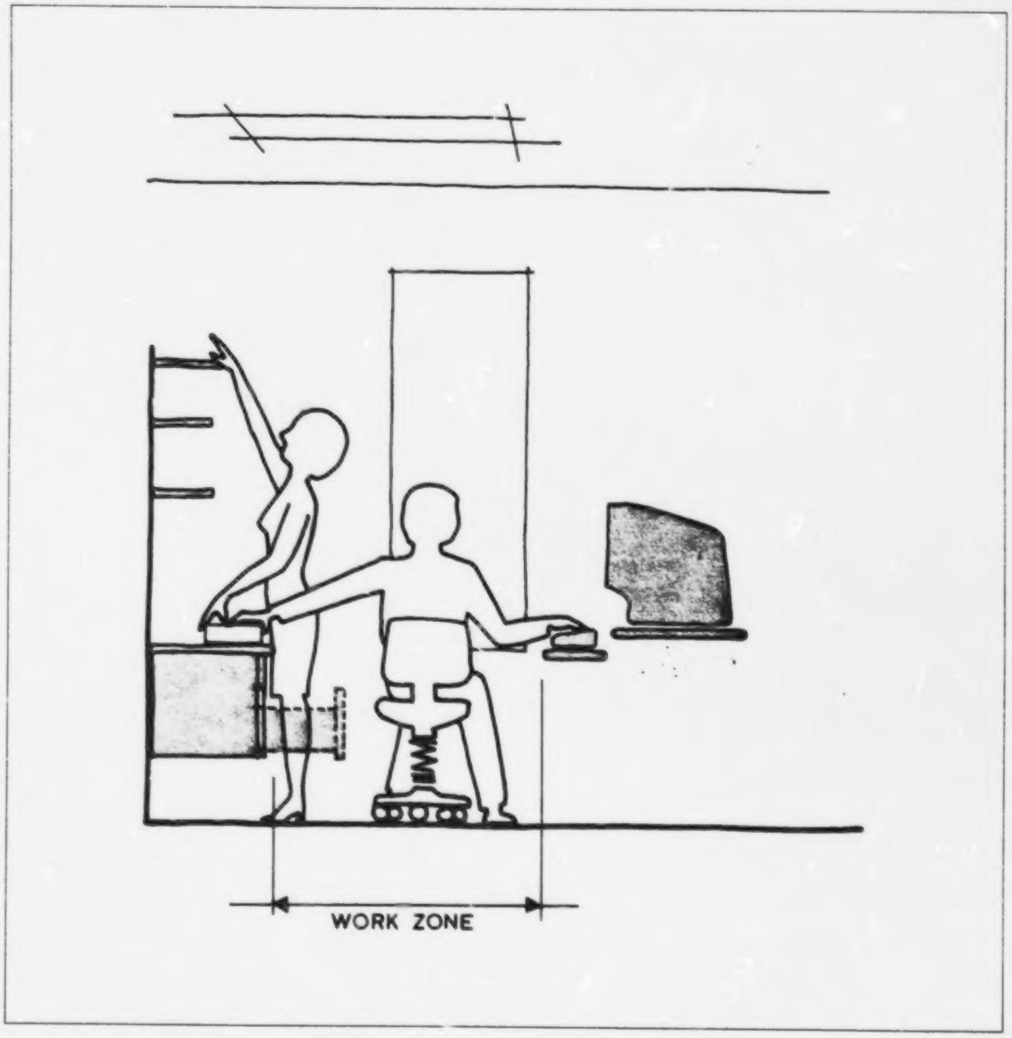
(PLAN PRODUCT EVALUATION)



7.0 Work zones shall provide adequate space to perform work activities, access stored items and circulate freely within the workstation.

CRITERION: Work Zone: = 1000mm - 1800mm

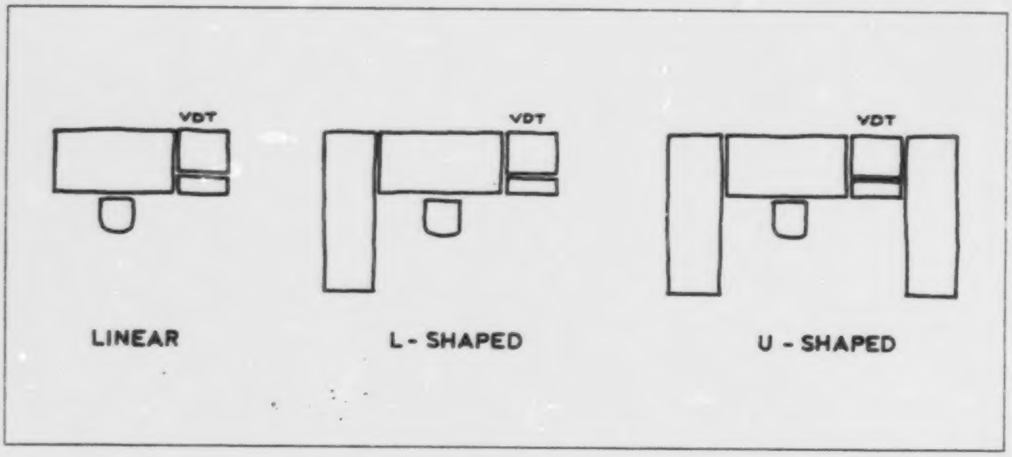
(OFFICE PLAN MEASUREMENT)



SPACE PLANNING REQUIREMENTS

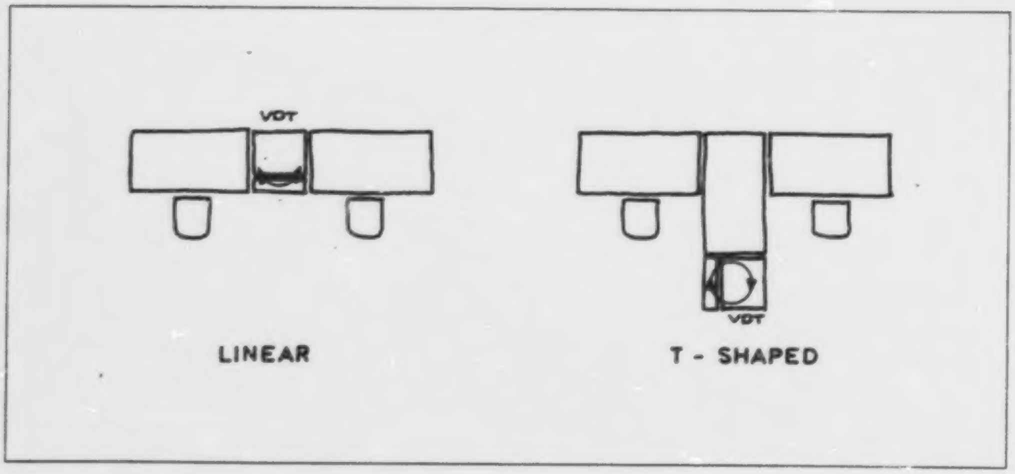
8.0 Single user workstations shall provide a variety of configurations for office planning.

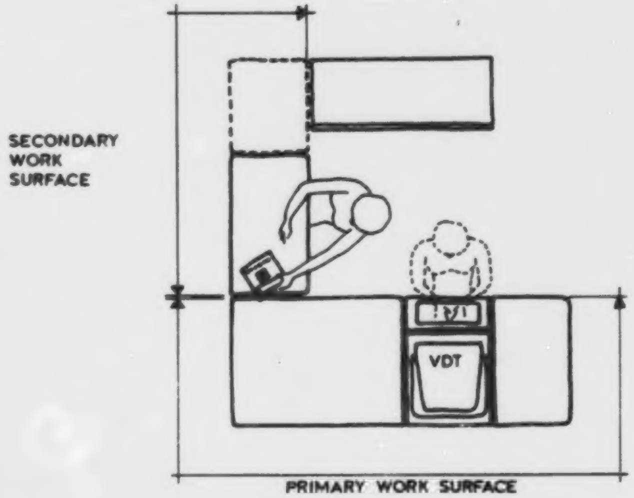
(PRODUCT LITERATURE EVALUATION)


VDT
VDT
VDT
LINEAR
L - SHAPED
U - SHAPED

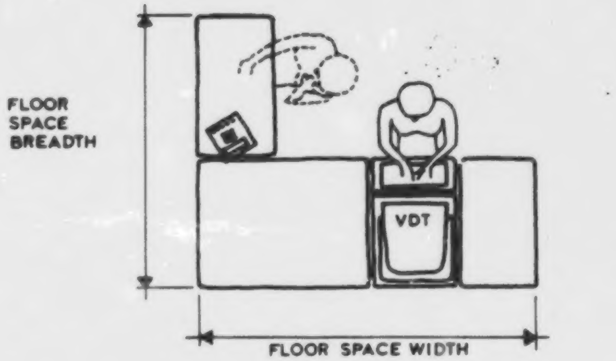
9.0 Multiple user workstations shall provide a variety of configurations for office planning.

(PRODUCT LITERATURE EVALUATION)


VDT
VDT
LINEAR
T - SHAPED


SECONDARY WORK SURFACE
VDT
PRIMARY WORK SURFACE

10.0 AREA REQUIREMENTS
- WORK SURFACES, SINGLE-USER WORKSTATION


FLOOR SPACE BREADTH
VDT
FLOOR SPACE WIDTH

11.0 AREA REQUIREMENTS
- FLOOR SPACE, SINGLE-USER WORKSTATION

DIMENSIONAL REQUIREMENTS

10.0 Single user workstations shall provide adequate primary and secondary work surface area for anticipated work activities, utilizing one VDT, keyboard, disc drive and CPU and must accommodate more electronic equipment which may be acquired later.

CRITERIA:

	Primary:	Secondary:
Word Processing	1.4m^2	.7m^2
Data Processing	1.7m^2	.9m^2
Professional Staff	1.7m^2	1.2m^2
Managerial Staff	1.7m^2	1.2m^2
Executive Staff	1.9m^2	1.2m^2

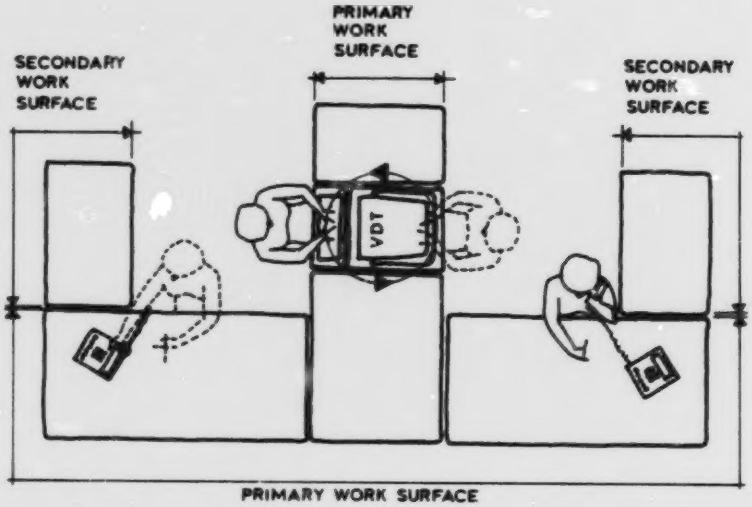
(PRODUCT MEASUREMENT)

11.0 Single user workstations shall provide adequate floor area for circulation, access to computer equipment and stored items, and standard furnishings.

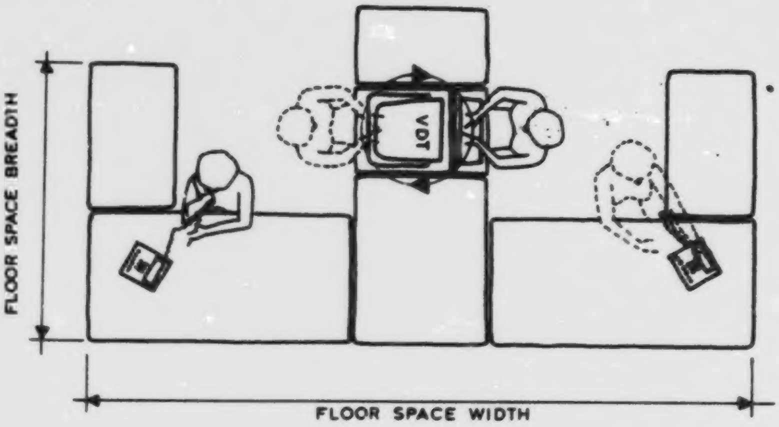
CRITERIA:

Word Processing:	5.0m^2
Data Processing:	5.8m^2
Professional Staff:	6.5m^2
Managerial Staff:	6.5m^2
Executive Staff:	12.0m^2

(OFFICE FLOOR PLAN MEASUREMENT)


PRIMARY WORK SURFACE
SECONDARY WORK SURFACE
SECONDARY WORK SURFACE
VDT
PRIMARY WORK SURFACE

12.0 AREA REQUIREMENTS
- WORK SURFACES, MULTIPLE-USER WORKSTATION


FLOOR SPACE BREADTH
VDT
FLOOR SPACE WIDTH

13.0 AREA REQUIREMENTS
- FLOOR SPACE, MULTIPLE-USER WORKSTATION

12.0 Multiple user workstations shall provide adequate primary and secondary work surface area for anticipated work activities.

CRITERIA:

	Primary:	Secondary:
Word Processing	4.1m^2	1.4m^2
Data Processing	4.6m^2	1.8m^2
Professional Staff	5.2m^2	2.4m^2
Managerial Staff	5.2m^2	2.4m^2

(PRODUCT MEASUREMENT)

13.0 Multiple user workstations shall provide adequate floor area for pedestrian and operator circulation, access to stored items, computer equipment and standard furnishings.

CRITERIA:

Word Processing:	14.0m^2
Data Processing:	16.0m^2
Professional Staff:	17.5m^2
Managerial Staff:	17.5m^2

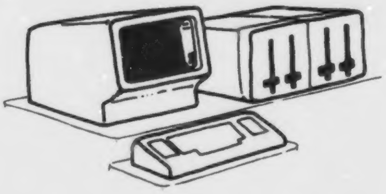
(OFFICE FLOOR PLAN MEASUREMENT)

EQUIPMENT SPACE REQUIREMENTS

14.0 If the workstation is to accommodate additional equipment beyond one CRT, keyboard, disk drive (dual) and central processor, then space requirements - work surface or floor area - shall be increased relative to space requirement for the additional equipment.

CRITERIA:		
	CRT:	$0.4m^2$
	Keyboard:	$0.2m^2$
	Printer:	$0.8m^2$
	Central Processor:	$0.3m^2$
	Disc Drive:	$0.4m^2$
	Telephone System:	$.06m^2$
	Dictaphone:	$.04m^2$

(FLOOR PLAN MEASUREMENT)



REFERENCES

1.0 Cakir, A., D.J. Hart and T.F.M. Stewart. "Visual Display Terminals" Wiley Interscience, Toronto, 1979.

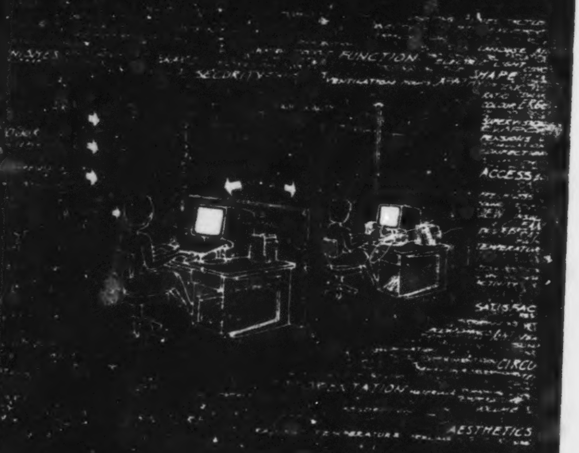
2.0 Diffrient, N., A. Tilley and J. Bardagjy. "Humanscale 7/8/9." The MIT Press, Cambridge Mass., 1981.

3.0 McCormick, E.J. "Human Factors in Engineering and Design." McGraw-Hill, New York, 1979.

4.0 National Aeronautics and Space Administration, "Anthropmetric Source Books (Vol. 1,2, and 3)." Reference Publication 1024. Scientific and Technical Information Office, 1978.

5.0 Panero, J. and M. Zelnik. "Human Dimension and Internal Space." Whitney Library of Design, New York, 1979.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SECURITY
VENTILATION
SHAPE
ACCESS
TEMPERATURE
SATISFAC
CIRCU
ORIENTATION
TEMPERATURE
AESTHETICS

WORK SURFACES

INTRODUCTION

Work surfaces play a key role in providing the requisite ergonomic features of an Electronic Work Station. The variety of work activities and increasing array of electronic equipment requires a parallel offering of work surface types, sizes and variations to meet such demands.

Simply stated, a system of surfaces should include adjustable support surfaces for keyboards and VDTs, primary work surfaces for work activities, secondary work surfaces which incorporate special surfaces for equipment security and a variety of surface shapes and sizes for conferencing and meeting.

The system of work surfaces should also provide a high degree of flexibility, which can be achieved on site without need for specialized labour or tools.

GENERAL REQUIREMENTS

1.0 The system shall provide, as standard componentry, a variety of work surface types which include adjustable primary, secondary and special shape and size components.

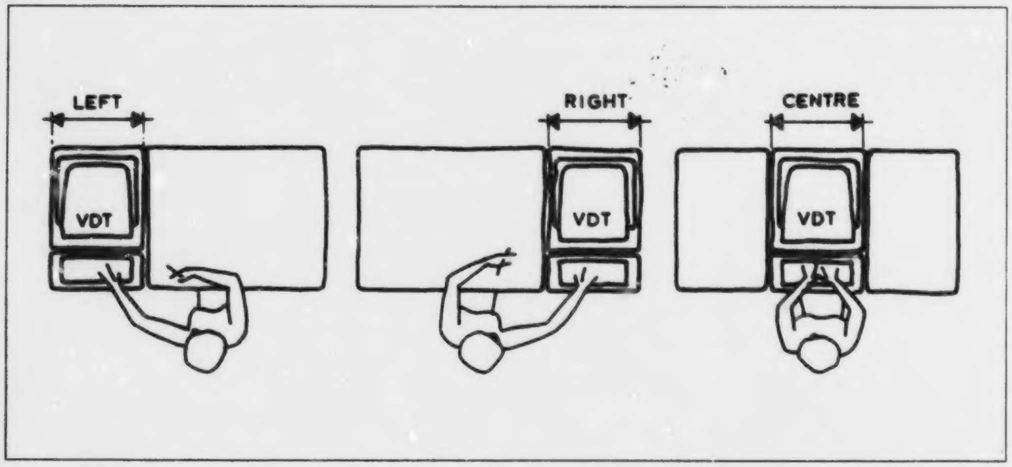
(PRODUCT SPECIFICATION)

2.0 All work surface types shall be designed to be demountable and independent of all other work station elements so they may be reconfigured at will without dismantling other system components.

(VISUAL INSPECTION/PRODUCT LITERATURE EVALUATION)

3.0 All work surface types shall be designed for right or left handed use. All work surface types shall be modular to facilitate planning needs. A range of modular sizes is preferred.

(PRODUCT LITERATURE EVALUATION)



DIMENSIONAL REQUIREMENTS

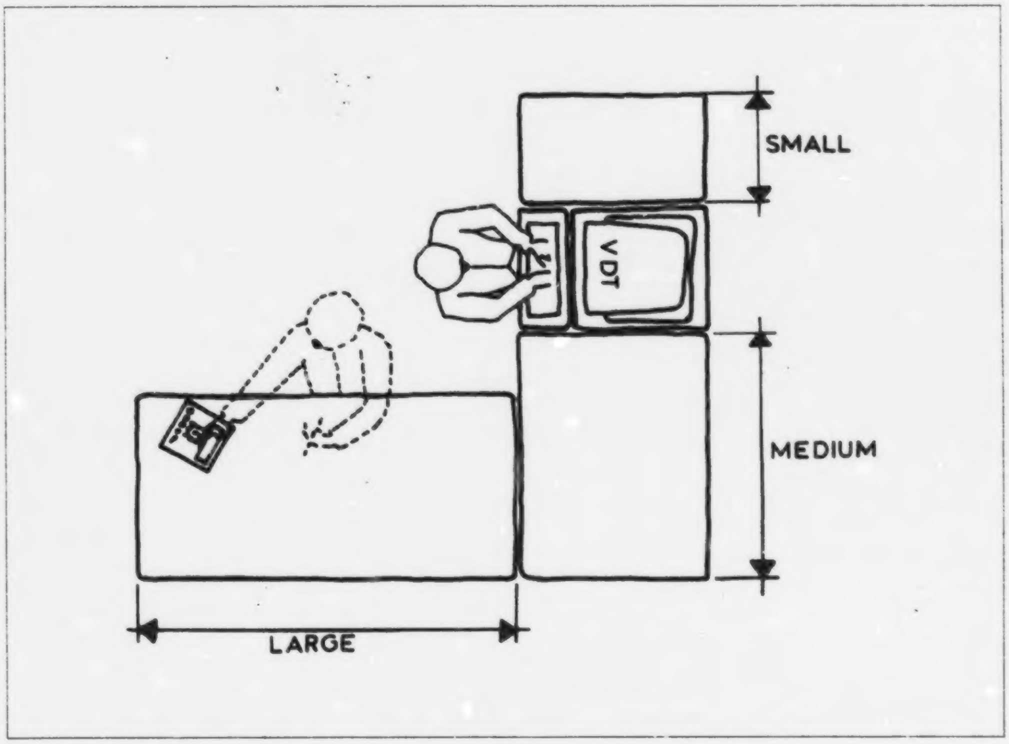
4.0 Primary work surfaces shall be available in a variety of widths and shall be dimensionally compatible with the work station module and interchangeable with surfaces for computer.

CRITERIA: Small: 750mm - 1200mm

Medium: 1000mm - 1200mm

Large: 1500mm - 1800mm

(PRODUCT MEASUREMENT)



5.0 Primary work surfaces shall provide adequate depth for computer aids, large format computer print-out documents, reference material and personal items.

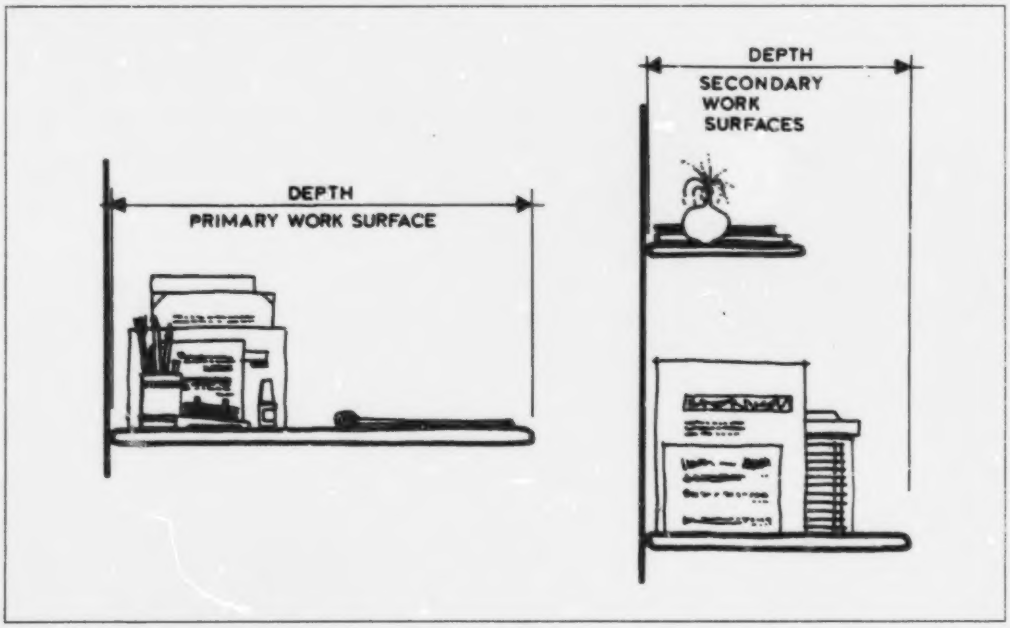
CRITERION: Depth = 900mm - 1000mm

(PRODUCT MEASUREMENT)

6.0 Secondary work surfaces shall provide adequate depth for reference manuals, large format computer print-outs and general office tasks.

CRITERION: Depth = 760mm - 900mm

(PRODUCT MEASUREMENT)


DEPTH
PRIMARY WORK SURFACE
DEPTH
SECONDARY
WORK
SURFACES

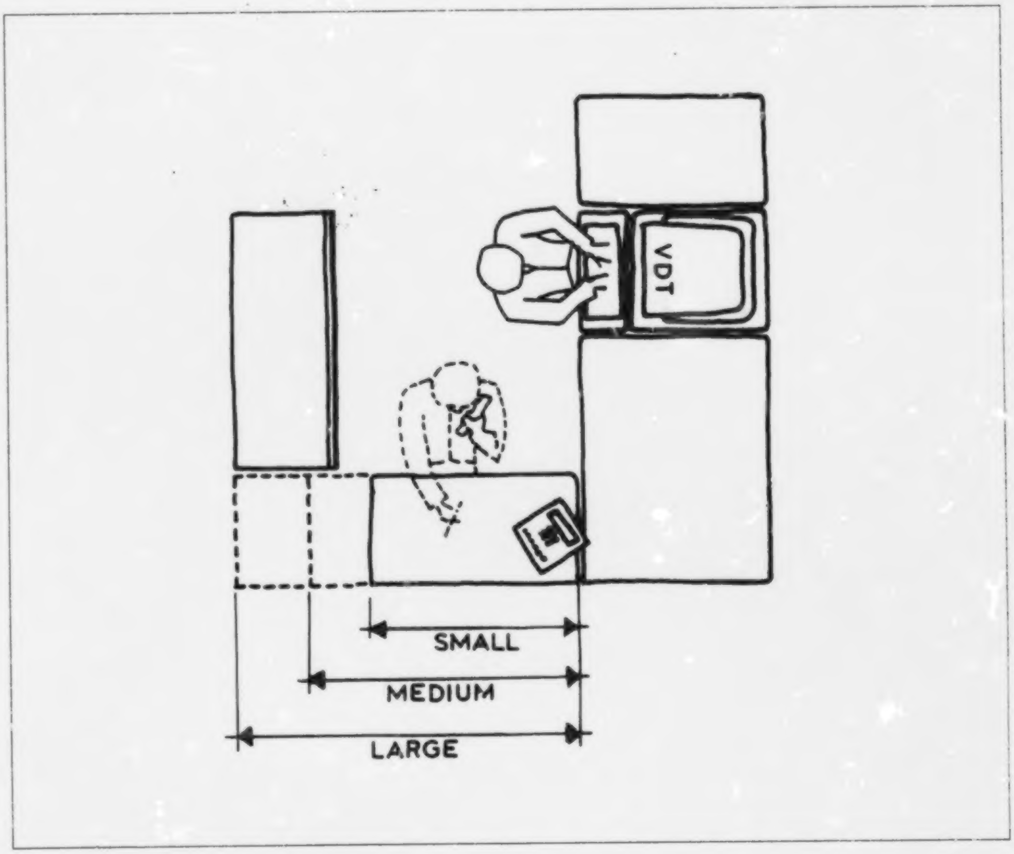
7.0 Secondary work surfaces shall be available in a variety of widths and shall be dimensionally compatible with primary and computer work surfaces.

CRITERIA: Small: 600mm - 900mm

Medium: 1000mm - 1200mm

Large: 1500mm - 1800mm

(PRODUCT MEASUREMENT)



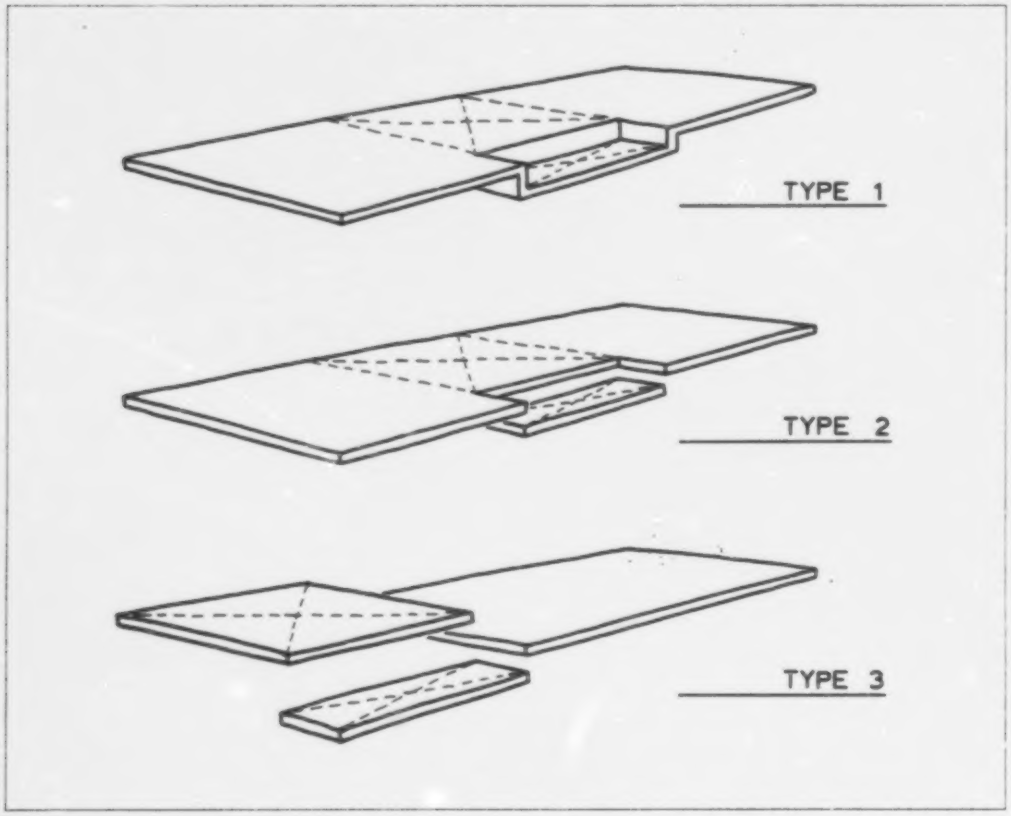
8.0 Computer work surfaces shall be available as standard componentry and be designed to accommodate all desk-top computer system sizes and configurations.

CRITERION: Type 1: Fixed height work surfaces

Type 2: Adjustable keyboard surface

Type 3: Adjustable keyboard and VDT surfaces (preferred)

(VISUAL INSPECTION/PRODUCT LITERATURE EVALUATION)



9.0 Computer work surfaces shall be sized to accommodate the variety of desk-top computer systems.

CRITERIA: VDT Surface

Width: W = 600mm - 700mm

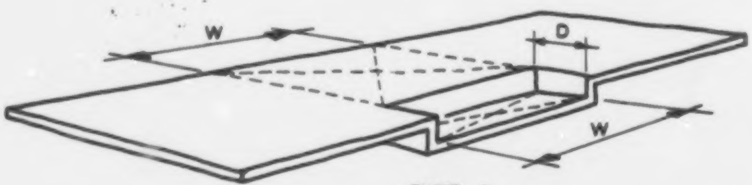
Depth: D = 600mm - 900mm

Keyboard Surface

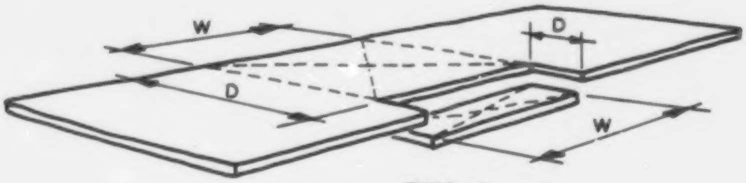
Width: W = 600mm - 760mm

Depth: D = 300mm - 340mm

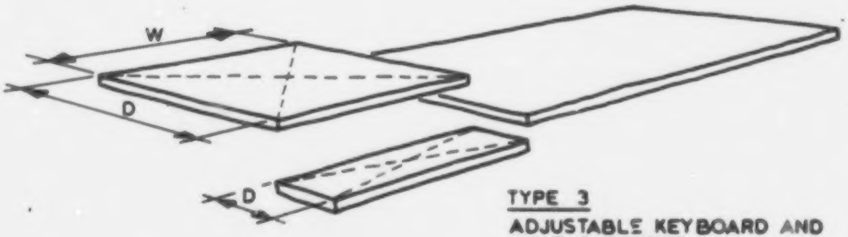
(PRODUCT MEASUREMENT)



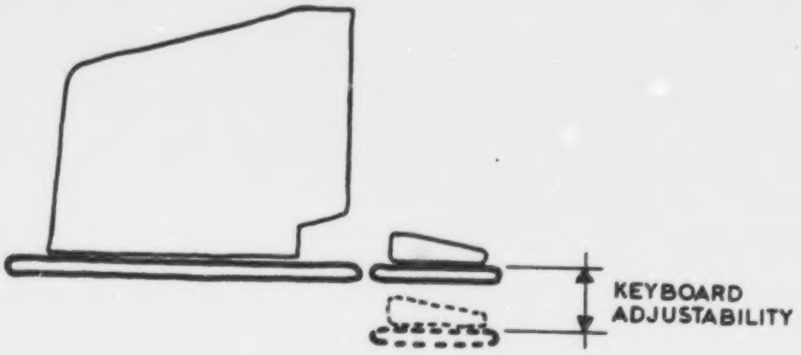
TYPE 1
FIXED HEIGHT WORK SURFACES



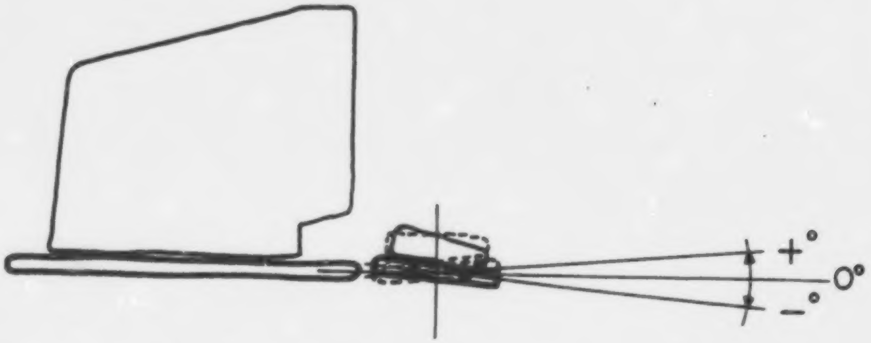
TYPE 2
ADJUSTABLE KEYBOARD SURFACE



TYPE 3
ADJUSTABLE KEYBOARD AND
V D T SURFACES


KEYBOARD
ADJUSTABILITY

KEYBOARD ADJUSTABILITY REQUIREMENTS - VERTICAL



KEYBOARD ADJUSTABILITY REQUIREMENTS - TILT

SURFACE ADJUSTABILITY REQUIREMENTS

10.0 Keyboard surfaces shall be adjustable within a range which can accommodate the variety of user size variations.

CRITERION: Keyboard vertical adjustment = 100mm - 150mm

(PRODUCT MEASUREMENT)

11.0 All keyboard surfaces shall be designed with integral tilting capabilities.

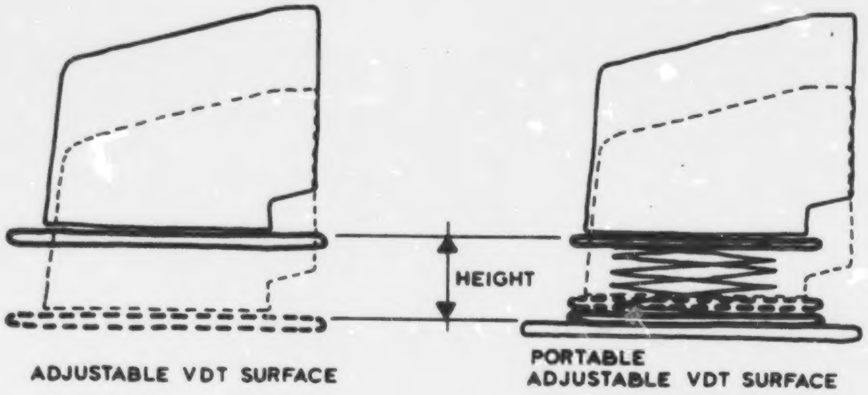
CRITERION: Rotation = ± 10°

(PRODUCT MEASUREMENT)

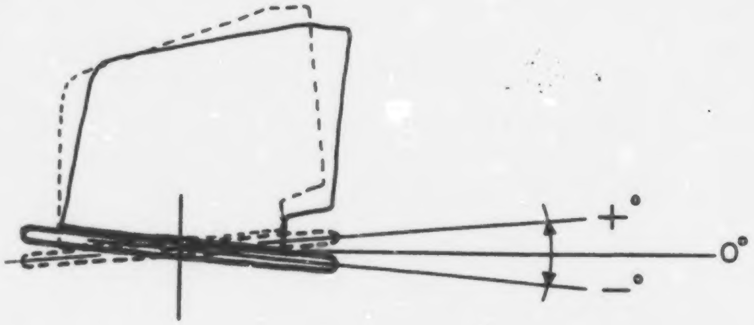
12.0 The design of the keyboard adjusting mechanism shall be low profile and not inhibit knee clearance or have exposed sharp edges, fasteners, etc., which may catch user garments or cause injury.

CRITERIA: Height: ≯ 130mm maximum
Depth: ≯ 460mm minimum

(VISUAL INSPECTION/PRODUCT MEASUREMENT)


HEIGHT
ADJUSTABLE VDT SURFACE
PORTABLE
ADJUSTABLE VDT SURFACE

VDT ADJUSTABILITY REQUIREMENTS - VERTICLE



VDT ADJUSTABILITY REQUIREMENTS - TILT

13.0 VDT surfaces shall be vertically adjustable to provide a range of viewing angles.

CRITERION: VDT vertical adjustment = 100mm - 150mm

(PRODUCT MEASUREMENT)

14.0 VDT support surfaces shall be designed with integral tilting capabilities.

CRITERION: Rotation = ± 10°

(PRODUCT MEASUREMENT)

15.0 All height and tilt controls shall be in clear view of the seated operator and designed to be easily activated.

(PRODUCT MEASUREMENT)

16.0 Adjustable surfaces for keyboard and VDT shall be designed to be non-slip to prevent equipment movement when surfaces are not level (See limits stated in Clause 14.0).

(VISUAL INSPECTION)

17.0 All work surfaces shall be designed to be easily repaired on site or to be easily replaced on site.

(VISUAL INSPECTION/PRODUCT LITERATURE EVALUATION)

18.0 Work surface finishes shall be non specular (matt finish) and of an average reflectance.

(REFLECTANCE MEASUREMENT)

REFERENCES

1.0 Cakir, A., D.J. Hart and T.F.M. Stewart, "Visual Display Terminals" Wiley Interscience, Toronto, 1979.

2.0 Diffrient, N., A. Tilley and J. Bardagjy, "Humanscale 7/8/9." The MIT Press, Cambridge, Massachusettes, 1981.

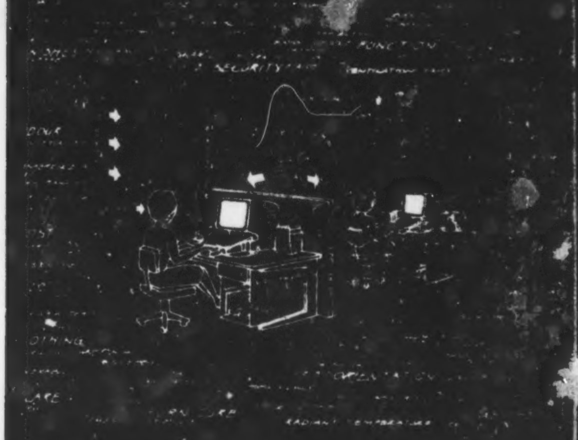
3.0 DIN, "Safety Regulations for Display Workplaces in the Office Sector" No. 2H 1/618 ed 10.80, 1980. (Translation)

4.0 McCormick, E. J., "Human Factors in Engineering and Design." McGraw Hill Book Company, New York, 1979.

5.0 National Aeronautics and Space Administration, "Anthropmetric Source Books (Vol. 1,2, and 3)." Reference Publication 1024. Scientific and Technical Information Office, 1978.

6.0 Panero, J. and M. Zelnik , Human Dimension and Interior Space. Whitney Library of Design, New York, 1979.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SECURITY
ORIENTATION
RADIANT TEMPERATURE

STORAGE

INTRODUCTION

Concurrent with the information revolution are the increasing needs for more flexible and sophisticated storage. Office automation technology with its accompanying media and support materials, poses a variety of new storage requirements for equipment, fiche, cassettes, floppy and hard disk formats, print-outs, etc. - all in addition to traditional needs for paper filing, general office supplies and personal items.

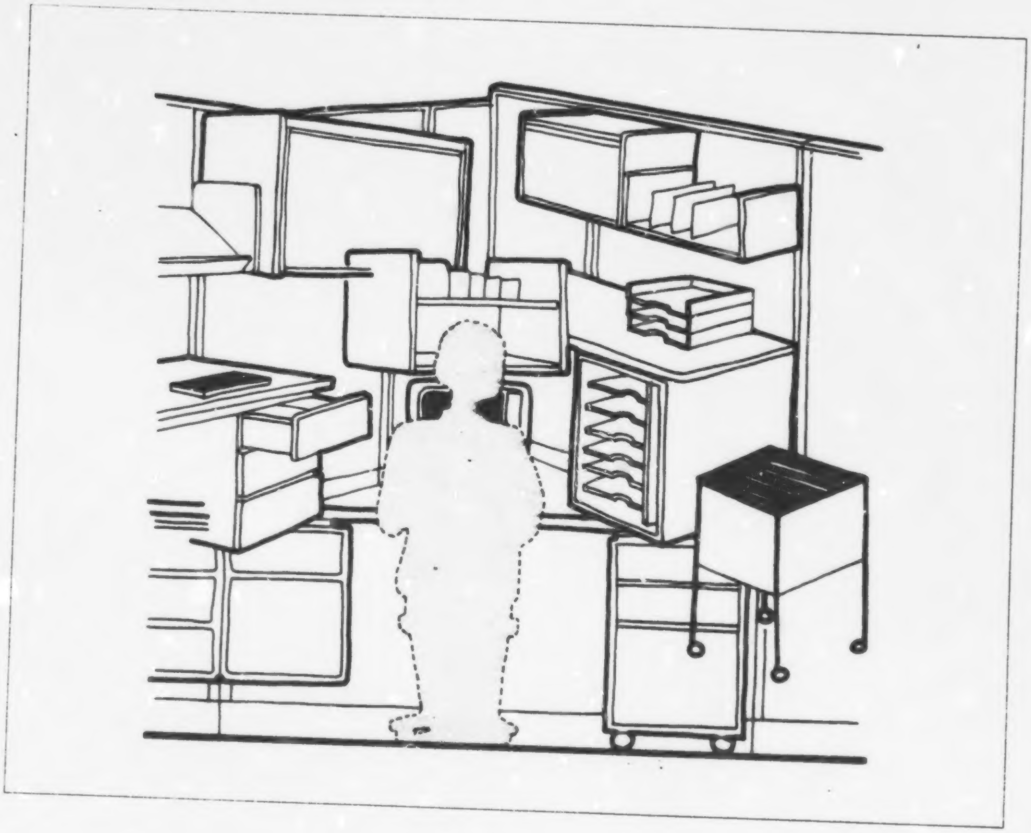
Security is more critical due to the ease with which large amounts of data stored on small magnetic media - disks or fiches - can be concealed and stolen.

In an office environment which is continually becoming more complex, the success of storage systems will be measured by their ability to store the broad spectrum of support materials in a flexible and reasonably economic and ergonomic manner.

GENERAL REQUIREMENTS

1.0 A variety of storage units (including mobile and fixed types) shall be available as standard componentry.

(PRODUCT SPECIFICATION)



2.0 Storage units shall be designed to be used singly, in groups or over work surfaces, as required.

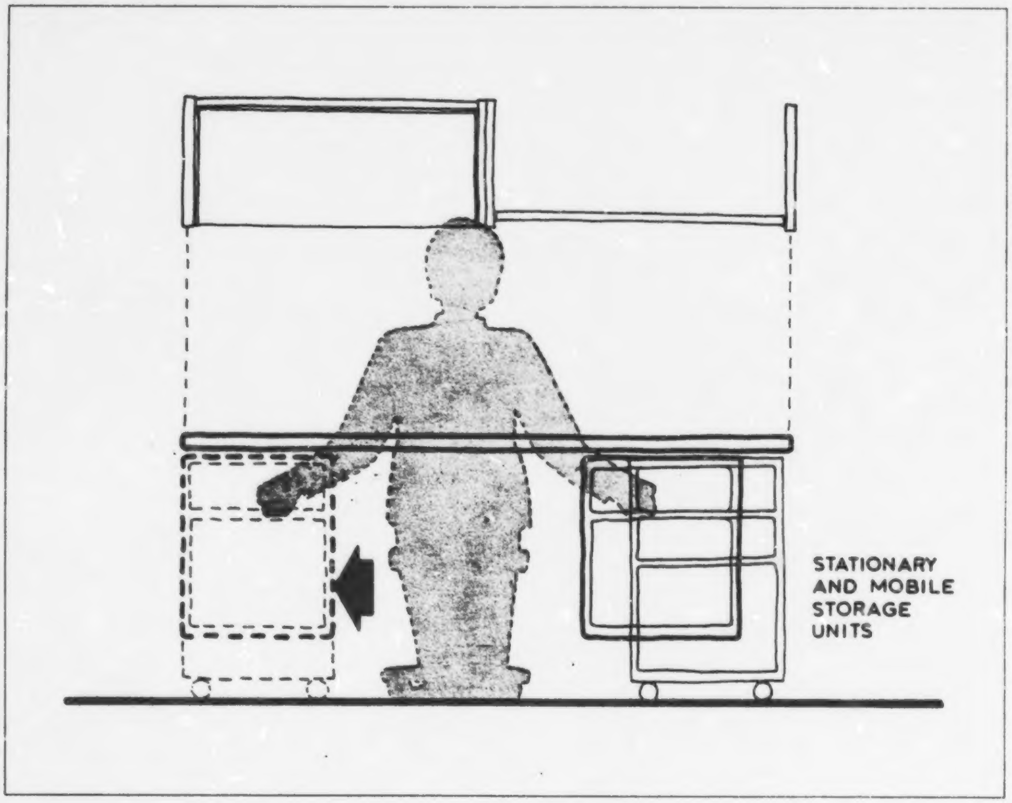
(PRODUCT LITERATURE EVALUATION)

3.0 Storage units shall be designed to accept handling binder systems for computer print-outs.

(PRODUCT LITERATURE EVALUATION)

4.0 All storage units shall be adaptable to left and right hand installations, as required.

(PRODUCT LITERATURE EVALUATION)


STATIONARY
AND MOBILE
STORAGE
UNITS

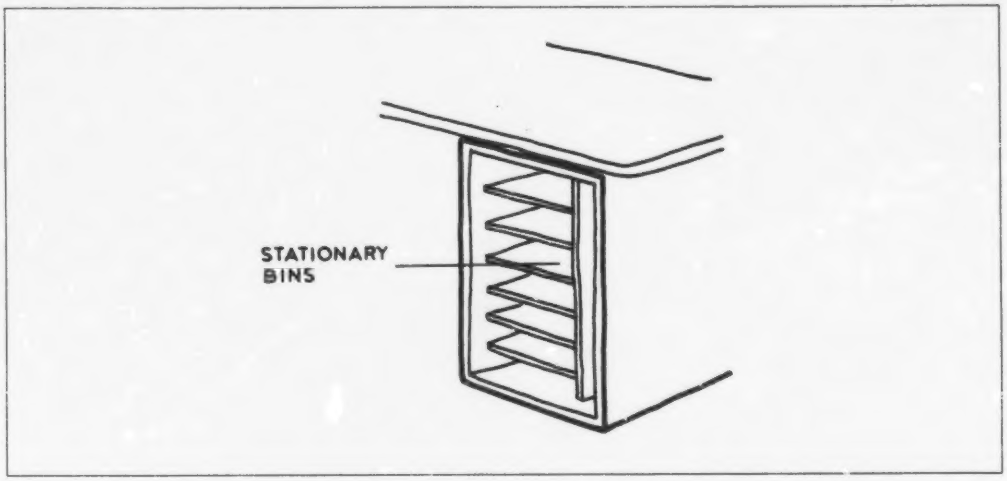
5.0 The storage system shall offer as standard componentry book end supports, paper trays and index card bins , fabricated of materials which match or coordinate with the storage system.

(VISUAL INSPECTION)

6.0 Stationery bins shall be available as standard componentry and shall provide an adequate number of sections for legal, letter or metric paper sizes.

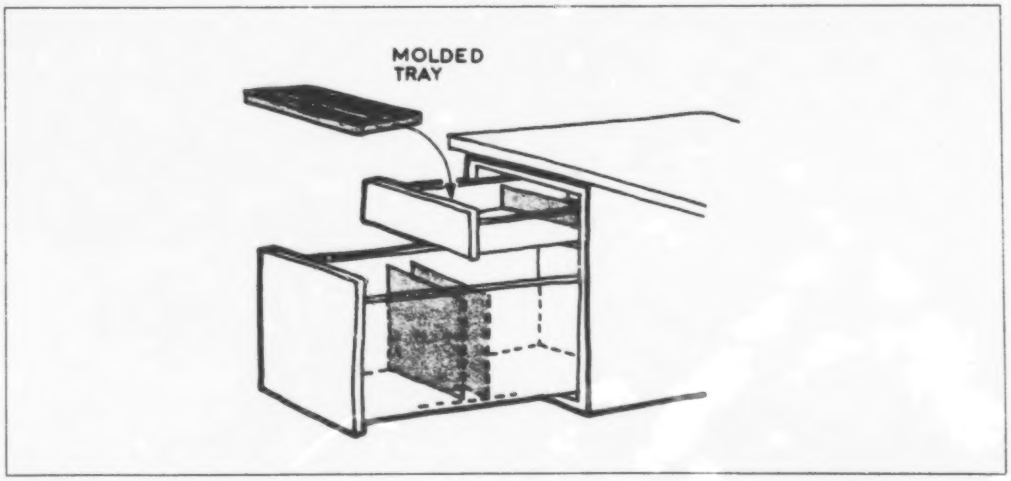
CRITERION: Minimum Number of bins = 6

(VISUAL INSPECTION/PRODUCT LITERATURE EVALUATION)



7.0 The modular drawer system shall provide as standards componentry stationery and drawer dividers, molded trays for pens, pencils, tacs, elastic band, paper clips, etc.

(VISUAL INSPECTION)



8.0 Mobile storage units shall be available in top or front access types, for access to stored contents.

(VISUAL INSPECTION)

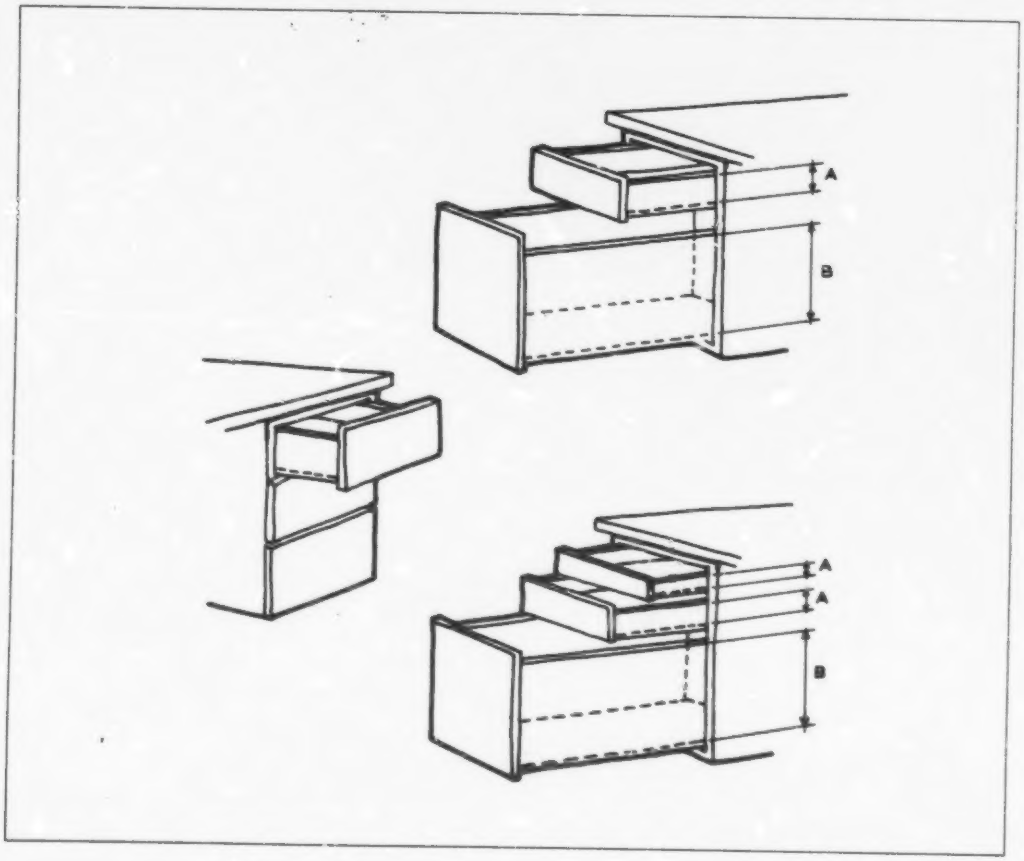
DIMENSIONAL REQUIREMENTS

9.0 The storage system shall offer as standard componentry modular, shallow and deep file drawers.

CRITERIA: Shallow Depth: A ≧ 75mm (min.)

Deep Depth: B ≧ 280mm (min.)

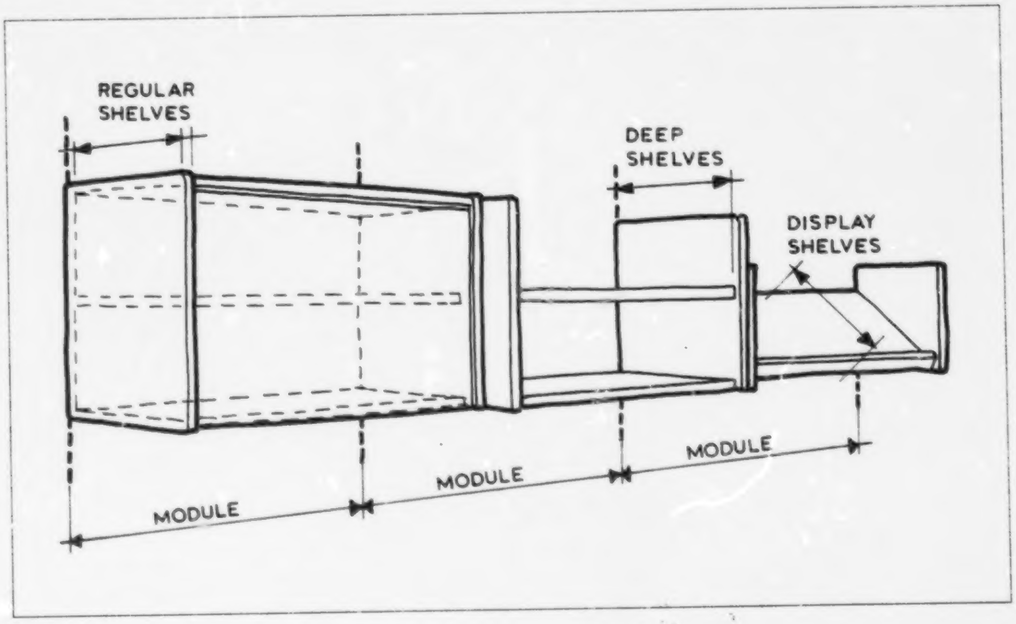
(PRODUCT MEASUREMENT)



10.0 A variety of shelving units enclosed or open, modular in design, shall be available in a range of sizes and styles to accommodate user needs.

CRITERIA:	Regular shelves:	250mm - 300mm
	Deep shelves:	300mm - 400mm
	Display shelves:	300mm - 350mm

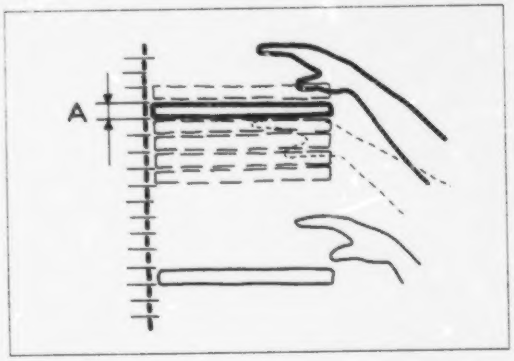
(PRODUCT MEASUREMENT)


REGULAR SHELVES
DEEP SHELVES
DISPLAY SHELVES
MODULE
MODULE
MODULE

11.0 Vertical location of shelves in work station shall be fully adjustable within discrete dimensional increments.

CRITERION: A = 25mm

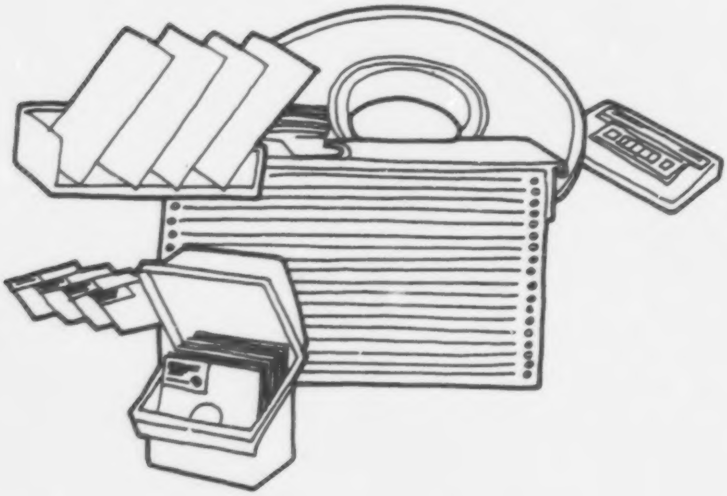
(PRODUCT MEASUREMENT)



12.0 Workstations shall provide adequate storage space, binding systems for files, magnetic media, writing supplies and personal items.

CRITERIA:	Stationery/Paper Files:	215 mm x 360 mm x 400 mm
	Magnetic Media:	
	Cassettes:	110 mm x 70 mm x 100 mm
	Floppy disks:	220 mm x 220 mm x 100 mm
	Computer Print-outs:	412 mm x 300 mm x 300 mm
	Writing Supplies:	400 mm x 500 mm x 200 mm
	Personal Items:	400 mm x 400 mm x 100 mm

(PRODUCT MEASUREMENT)



13.0 All storage units and shelving shall be constructed of materials which match or coordinate with system furnishings.

(VISUAL INSPECTION)

14.0 All drawers shall utilize high quality, full-extension ball bearing slides and all cabinet doors high quality, all metal (or equivalent) hinges.

(PRODUCT SPECIFICATION)

15.0 Storage units both mobile and fixed, shall allow for a variety of drawer combinations.

(VISUAL INSPECTION)

16.0 Mobile storage units shall be equipped with four high quality casters with ball bearing assemblies.

(PRODUCT SPECIFICATION)

17.0 Shelving support shall be designed to prevent the possibility of accidental disconnections which can cause shelving units to collapse.

(VISUAL INSPECTION)

18.0 Shelving storage units shall be designed to accept a lockable door to secure stored contents.

(VISUAL INSPECTION)

19.0 All doors or shelving storage units shall be designed with grip area which prevents "finger catching" when unit is closed.

(VISUAL INSPECTION)

20.0 All shelf edges shall be rounded along edges facing users, and storage unit panels shall have well broken edges for safety.

(VISUAL INSPECTION)

21.0 All molded plastic parts shall be high quality injection molded plastic, or equivalent, with finished edges.

(VISUAL INSPECTION)

SECURITY REQUIREMENTS

22.0 All storage units, mobile and fixed shall permit locking of a single drawer (or door), or any combination of drawers by activating one lock.

(VISUAL INSPECTION)

23.0 Lock systems shall be unaffected by storage unit location and be easily accessed and activated.

(VISUAL INSPECTION)

24.0 Lock bolt and plate construction shall be fabricated of metal or material of equivalent strength and durability utilizing tamperproof fasteners.

(VISUAL INSPECTION/PRODUCT LITERATURE)

25.0 Mobile and fixed storage units shall be designed to be locked to some fixed furnishing element to prevent theft of entire unit.

(VISUAL INSPECTION)

CONSTRUCTION REQUIREMENTS

26.0 Drawer Cycle Test: The storage unit shall be placed in its normal position and a loaded drawer, shall be cycled (open/close) at a rate of 15 cycles per minute, for 100,000 cycles.

CRITERION: No failure or wear affecting use of drawer.

(ANSI/BIFMA)

27.0 Out Stop Test: The drawer storage unit shall be designed to withstand an abnormal pull-out force on drawer slide hardware. Each drawer, uniformly loaded, shall be cycled five times.

(ANSI/BIFMA)

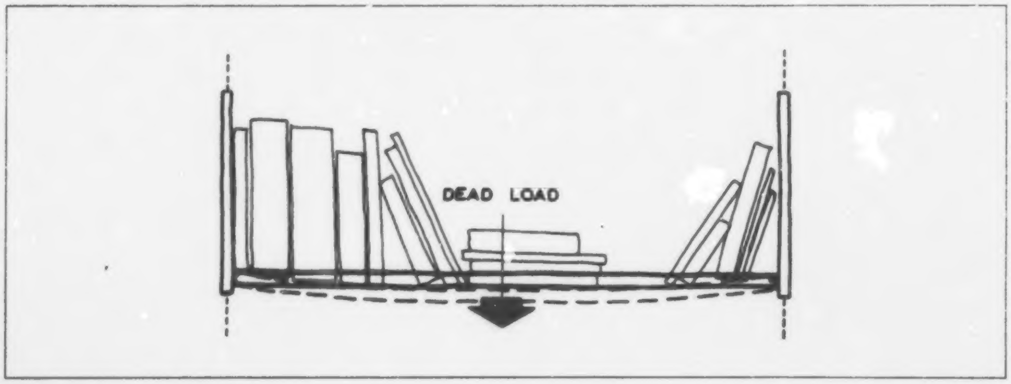
28.0 Rebound Test: All drawers shall not require excessive force to open or close and shall operate smoothly throughout their full travel.

(ANSI/BIFMA)

29.0 Shelving dead load test: All shelves shall be designed to withstand vertical downward force which shall be applied 10 times at a rate not exceeding 15 cycles per minute over an area 100 mm x 100 mm mid-way along the shelf's length and depth.

CRITERION: 53 Kg. per Linear Meter

(BSI 4875: PART 2: 1977)



REFERENCES

1.0 Canadian Labour Congress "Towards a More Humanizing Technology: Exploring the Impact of Visual Display Terminals on Health and Working Conditions" Ottawa, December 1982.

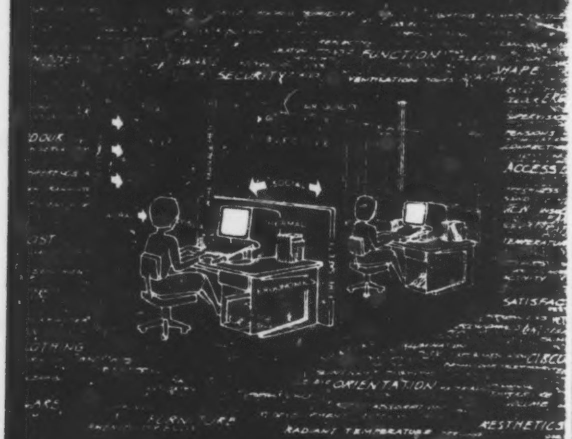
2.0 Diffrient, N., A. Tilley and J. Bardagjy, "Humanscale 1/2/3 and 4/5/6." The MIT Press, Cambridge, Massachusetts, 1974 and 1981.

3.0 Panero, J. and M. Zelnik, "Human Dimension and Interior Space." Whitney Library of Design, New York, 1979.

4.0 British Standard Institution "Specification for Strength and Stability of Domestic and Contract Furniture," BS 4875: Part 2-1977.

5.0 American National Standards Institute "American National Standard for Office Furnishings - Desk Products - Tests," ANSI/BIFMA 1983, New York, 1983.

ELECTRONIC OFFICE DESIGN GUIDE

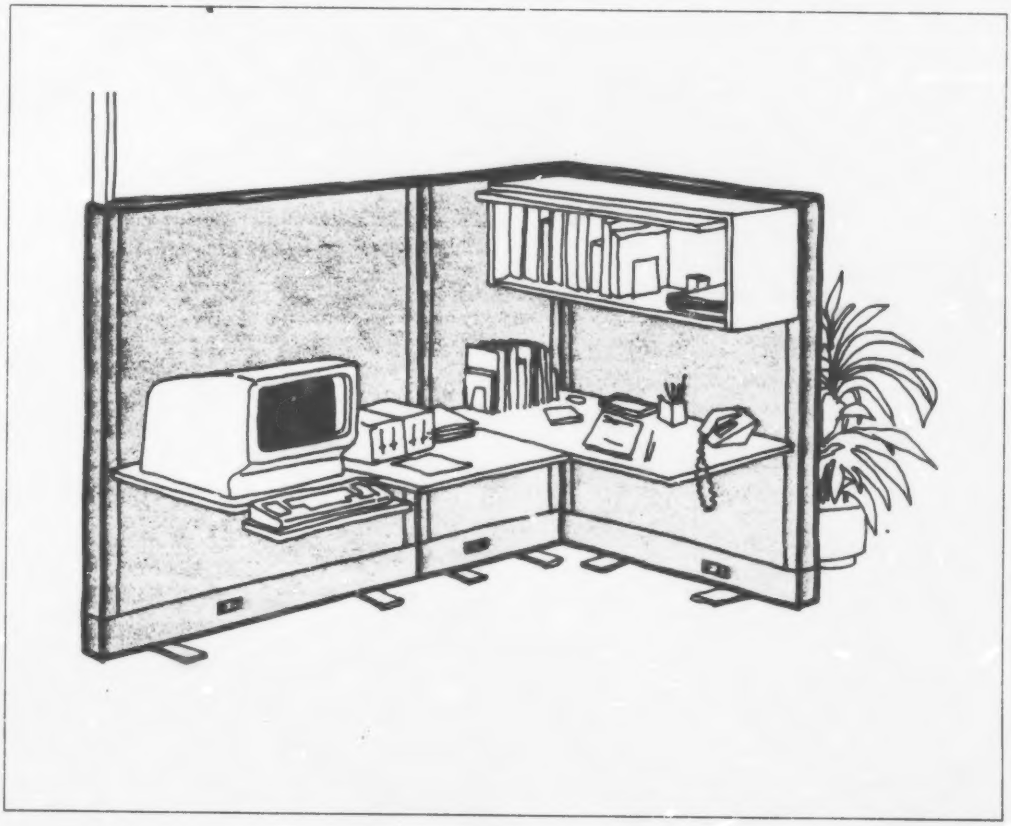

FUNCTION
SECURITY
VENTILATION
SHAPE
AIR QUALITY
SOCIAL
ACCESS
ORIENTATION
FURNITURE
RADIANT TEMPERATURE
AESTHETICS

PANELS

INTRODUCTION

Panels act as the spine of a furnishing system. They can be the primary determinants of the system's ability to meet all planning and user requirements. Additionally, panels must now provide for integrated wire management, be compatible with the wide variety of work and computer surfaces, possess good acoustic qualities and provide task/ambient lighting capabilities and, ideally an integrated signage system.

As the spine of the overall furnishing system, the panels provide the structure. They must be stable and easily configured, by nonprofessional staff with minimum assembly time.



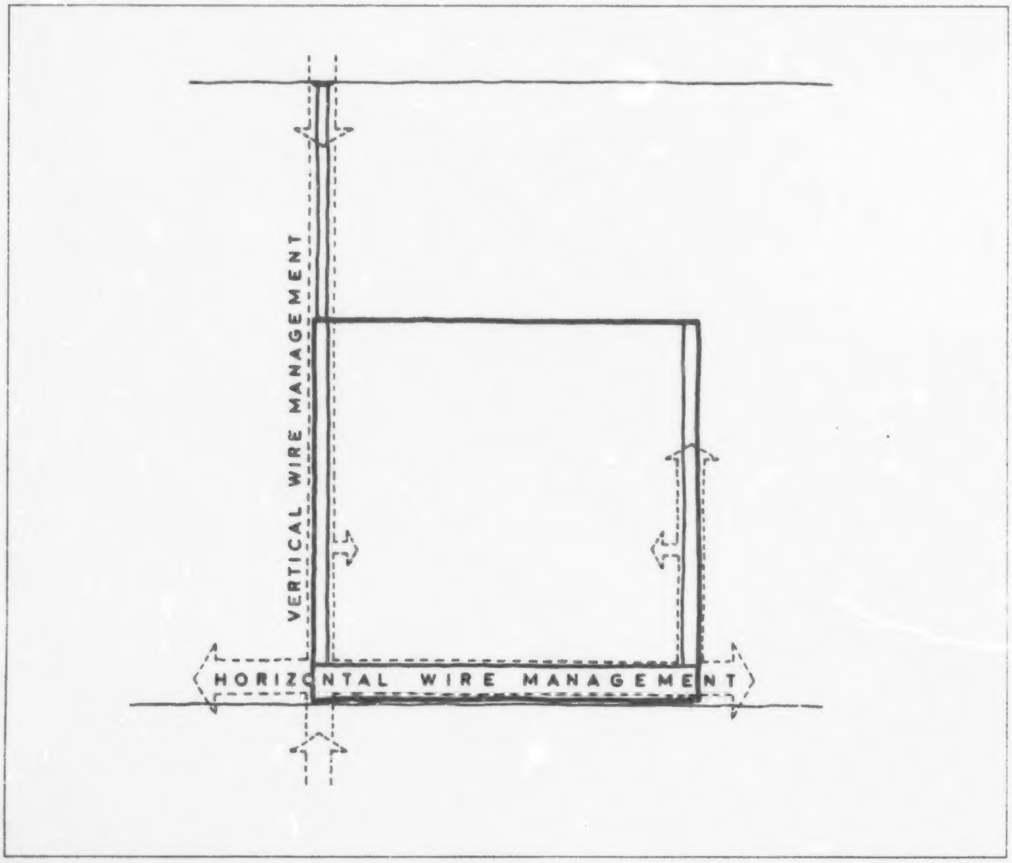
GENERAL REQUIREMENTS

1.0 The panel system shall provide options of finish which include fabric covers, high-pressure plastic laminate - or equivalent - and wood veneer.

(PRODUCT SPECIFICATION)

2.0 Acoustical qualities of panels are integrally linked with those of the workstation in particular and the building surrounds in general. (*cf* Acoustic Section)

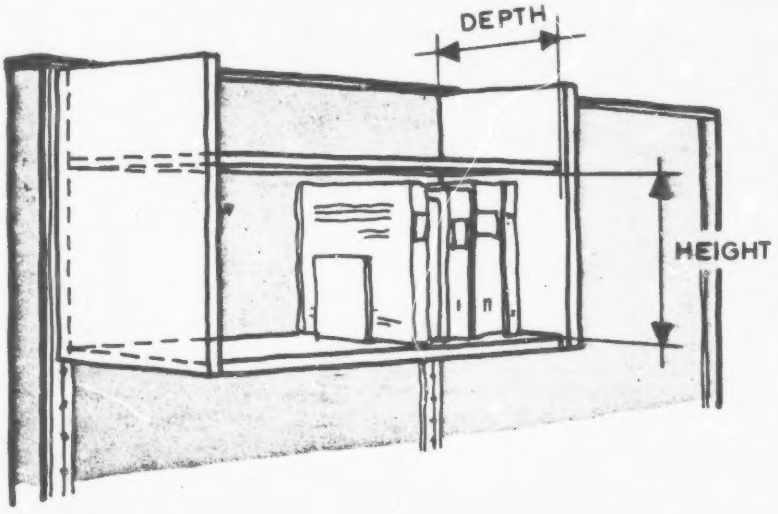
3.0 The provision of vertical and horizontal wire management to accommodate communication, data and power lines requires detailed considerations. With respect to the panels, per se, the construction should incorporate plenums for wire management. (*cf* Wire Management Section)



4.0 Panels with integrated storage shall provide sufficient shelf and vertical height between shelves for document storage.

CRITERIA:	Shelf depth:	300mm - 350mm
	Height between shelves:	200mm - 350mm

(PRODUCT MEASUREMENT)



5.0 Panels shall be available in widths that are evenly divisible by the furnishing system module size and not exceed a width that can be easily managed and moved throughout a building.

CRITERION: Width < 1600mm

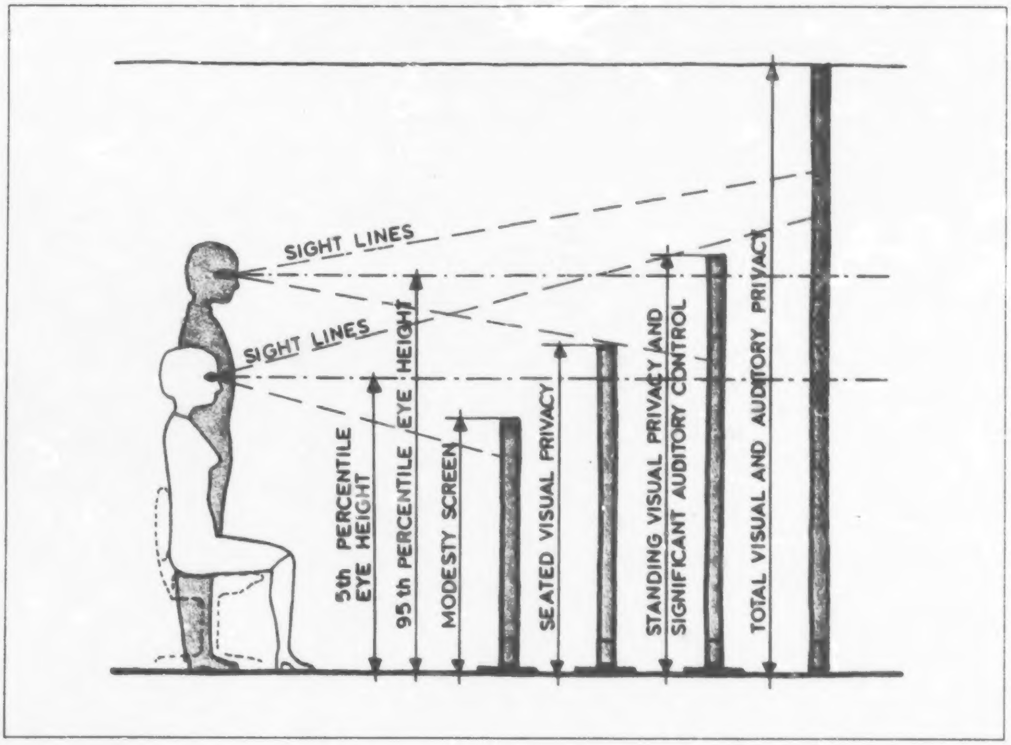
(PRODUCT SPECIFICATION)

6.0 The panel system shall provide a series of panel heights to meet planning requirements for the office.

CRITERIA: HEIGHTS

Modesty screen:	730mm - 1050mm
Seated Visual Privacy:	1050mm - 1500mm
Standing Visual and Acoustic Privacy:	1700mm - 1850mm
Total Visual and Acoustic Privacy:	Full Height

(PRODUCT SPECIFICATION)

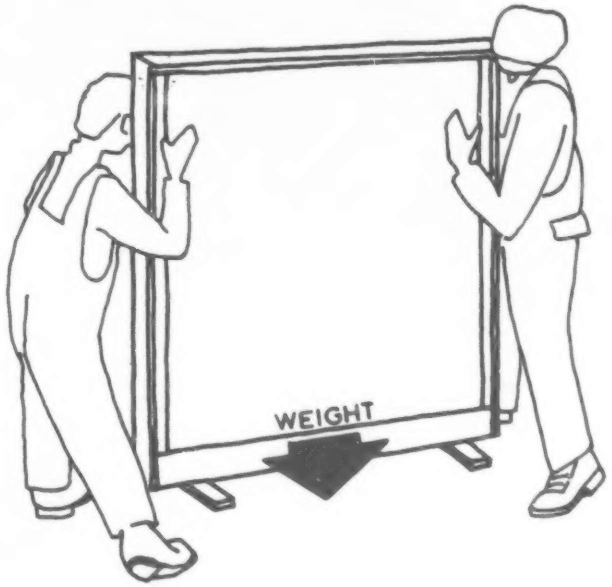

SIGHT LINES
SIGHT LINES
5th PERCENTILE EYE HEIGHT
95 th PERCENTILE EYE HEIGHT
MODESTY SCREEN
SEATED VISUAL PRIVACY
STANDING VISUAL PRIVACY AND SIGNIFICANT AUDITORY CONTROL
TOTAL VISUAL AND AUDITORY PRIVACY

WEIGHT REQUIREMENTS

7.0 The panel weight shall not exceed the weight lifting capabilities of service people.

CRITERION: Panel weight < 40.0 kg

(PRODUCT MEASUREMENT)

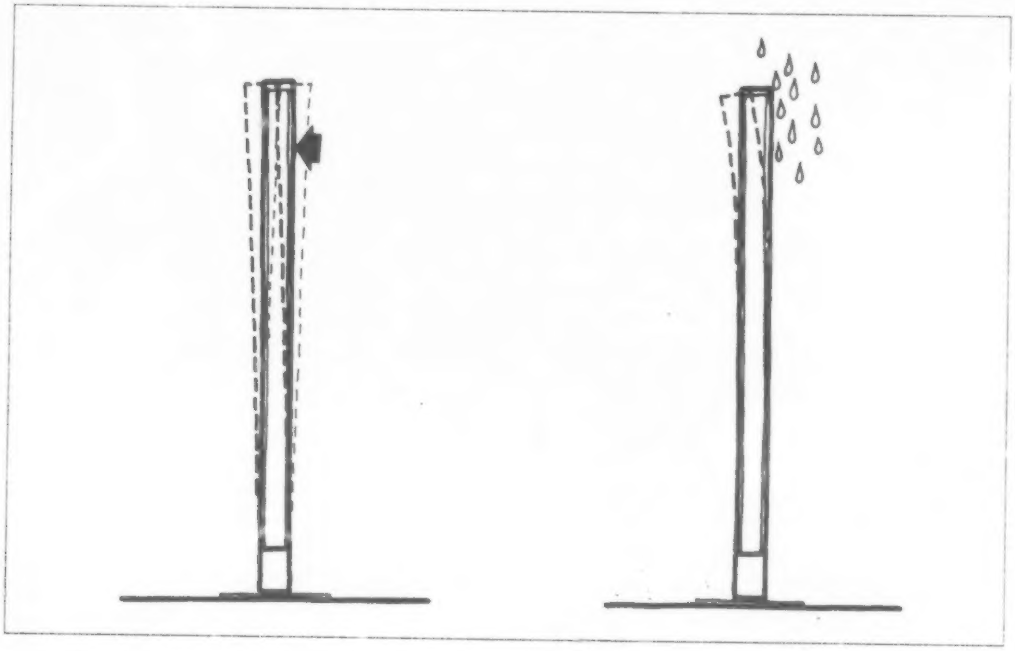


CONSTRUCTION REQUIREMENTS

8.0 Panels shall be constructed of high quality materials and be rigid in construction to prevent structural failure or permanent distortion under normal use.

(BS4875: PART 2)

9.0 All panels shall be constructed such that normal environmental conditions will not cause distortion.



(BS4875: PART 2)

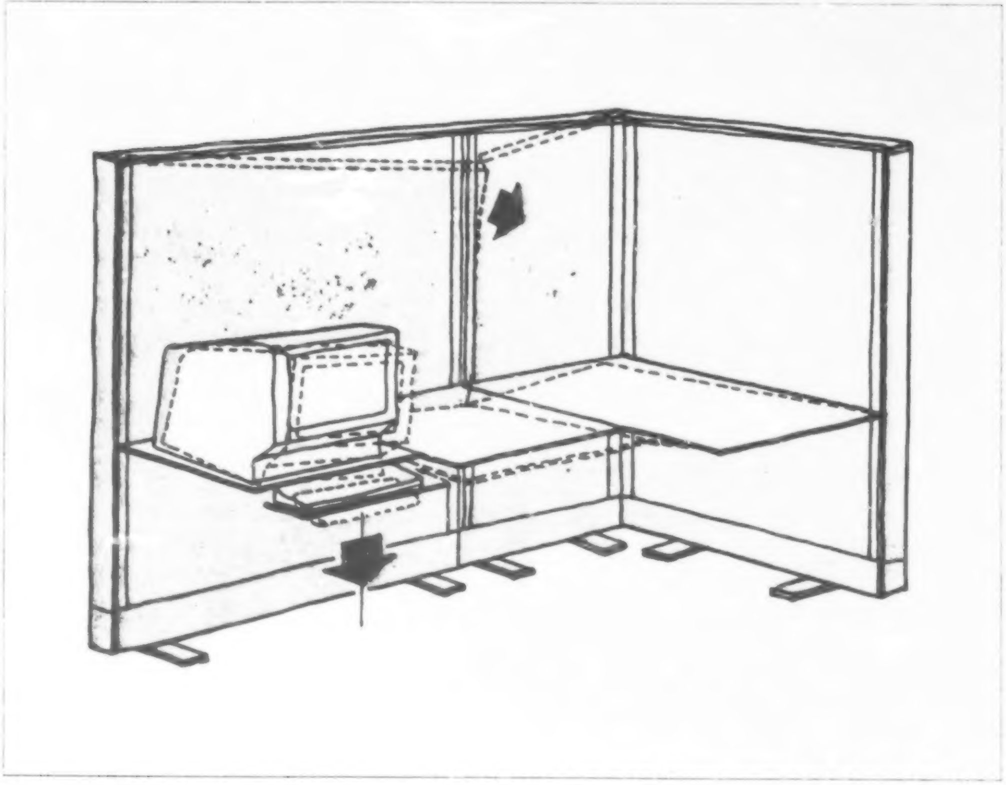
10.0 All panels shall be designed so that replacement, refinishing or repairing of exterior removable surfaces by unskilled labour can be done on site, without replacement of entire product.

(VISUAL INSPECTION)

11.0 Panel systems loaded with cantilevered work or computer surfaces units, and storage units, shall be vertically stable to prevent knock-down, to permit alignment between panels and to minimize operational vibrations which would affect keyboarding or work activities.

(Note: Vibrational problems are more evident with printers.)

(BS4975: PART 2)



PANEL SUPPORT REQUIREMENTS

12.0 All panel types shall be capable of standing independently and interconnected with adjacent panels, fully loaded.

(VISUAL INSPECTION)

13.0 All panel supports, including feet, glides, buttresses and gables shall not protrude excessively beyond the nominal thickness of the panel.

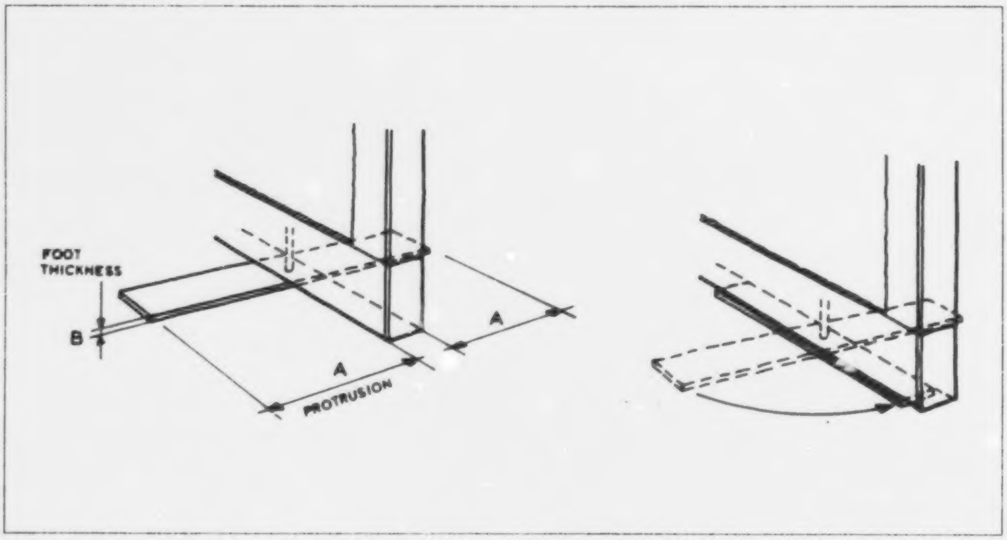
CRITERION: Protrusion: A $<$ 200 mm

(PRODUCT MEASUREMENT)

14.0 All panel supports shall be low profile to minimize interference with table, desk and chair legs and casters and, be "catch-free" to allow panels to be slid across floor surface without damaging floor covering.

CRITERION: Foot thickness: B $<$ 7.0 mm

(PRODUCT EVALUATION)



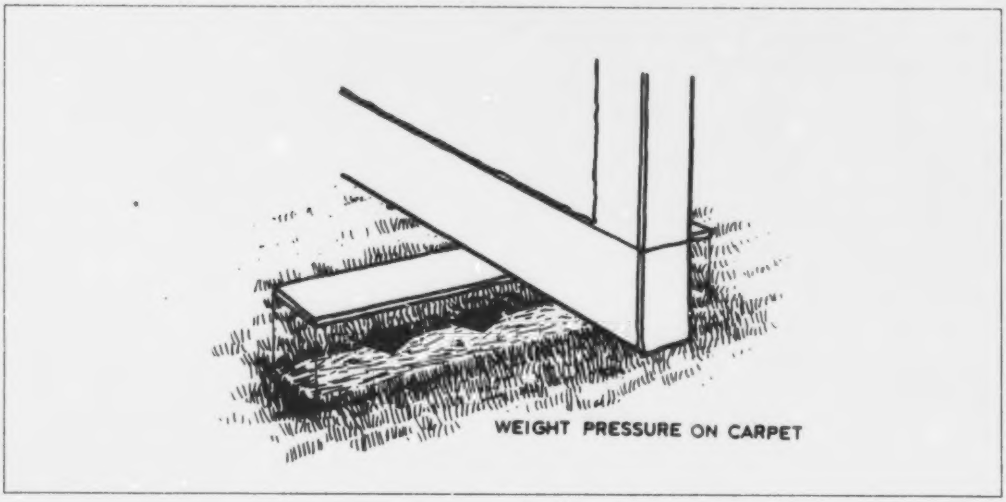
15.0 Panel supports shall be designed to be removable or retractable to a minimal dimension, equal to or less than the overall panel thickness for packaging, storage and shipping of panel.

(PRODUCT SPECIFICATION)

16.0 Panel supports shall be designed to prevent damage to the floor surface. Contact area of panel supports shall be maximized to reduce carpet damage. Pressure on carpet shall not exeed the interior:

CRITERION: Pressure = 10 kg/sq cm

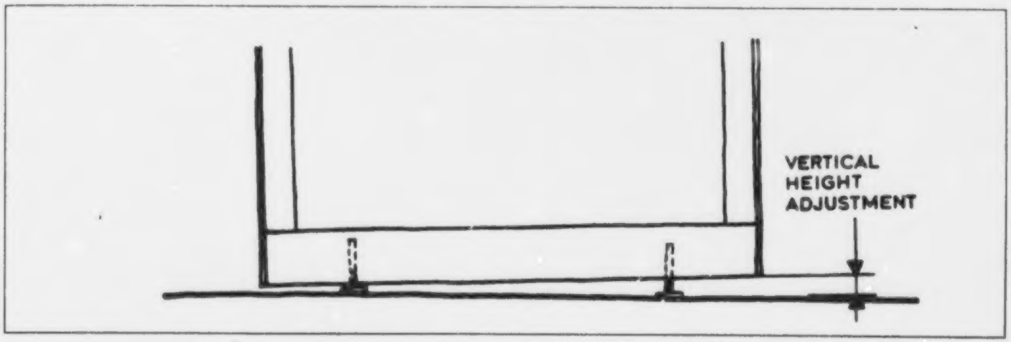
(PRODUCT EVALUATION)


WEIGHT PRESSURE ON CARPET

17.0 Panel bases shall have two independent integrated supports which can be easily adjusted vertically to accommodate height variations in the floor surface.

CRITERION: Vertical Height Adjustment = 60 mm

(PRODUCT EVALUATION)


VERTICAL
HEIGHT
ADJUSTMENT

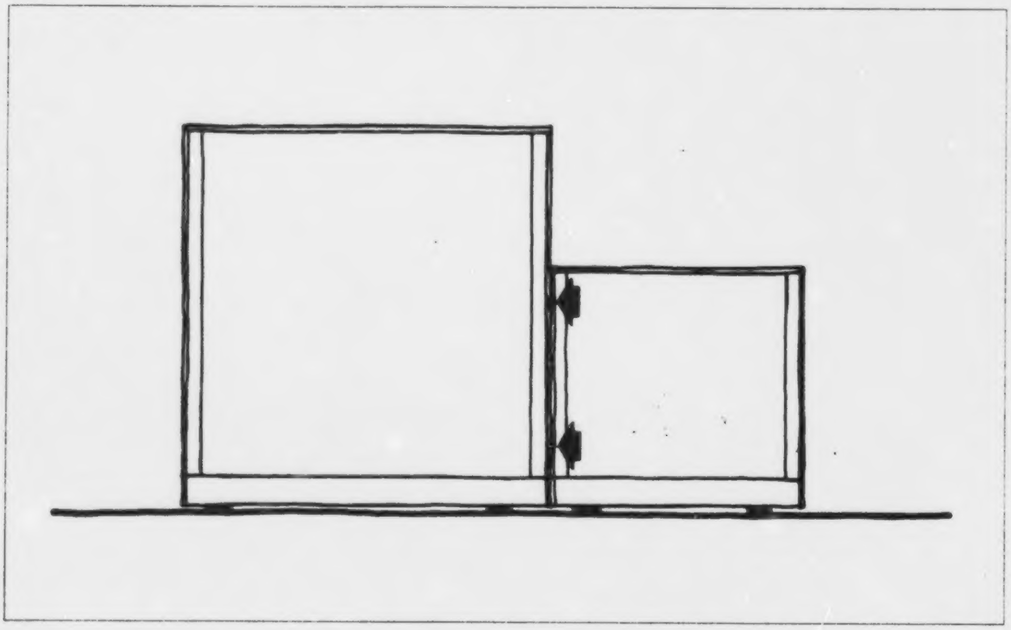
PANEL CONNECTOR REQUIREMENTS

18.0 Panels shall be designed with integrated, quick-release connectors to allow panels to be interconnected in a fast, and stable manner.

(VISUAL INSPECTION)

19.0 Connectors shall be designed to allow interconnection of panels of different heights, on-site, by unskilled labour with few tools. Connectors or attachments shall not have sharp edges penetrating wireways.

(VISUAL INSPECTION)



20.0 Connectors shall provide for panels to be connected in a variety of configurations: A panel system which can be configured infinitely is desirable.

CRITERIA: CONFIGURATIONS

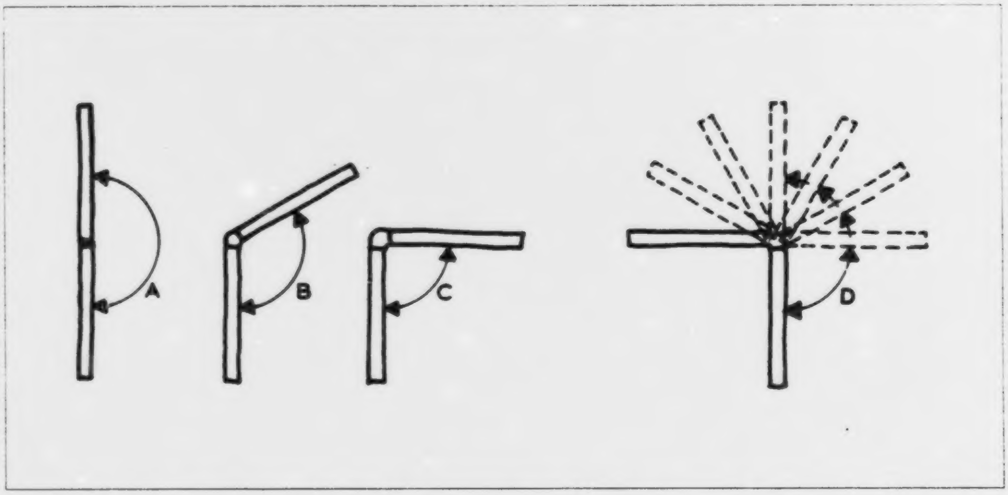
A. 180°

B. 120°

C. 90°

D. Infinitely

(VISUAL INSPECTION)



REFERENCES

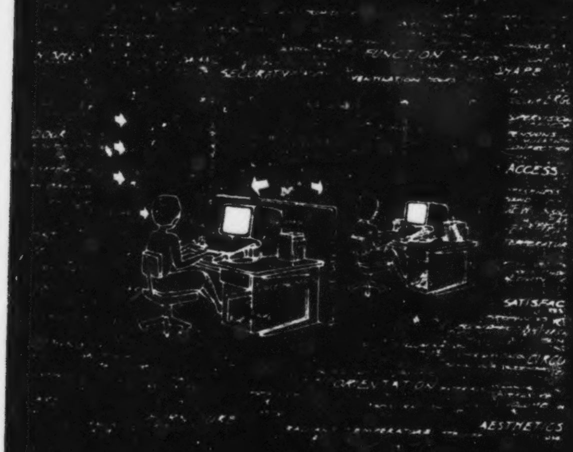
1.0 American National Standards Institute. "American National Standard for Office Furnishings - Desk Products - Tests"; ANSI/BIFMA 1983. ANSI, New York, 1983.

2.0 British Standards Institution. "Specification for strength and stability of domestic and contract furniture," BS 4875: Part 2 - 1977.

3.0 Panero, J. and Zelnik, M. "Human Dimension and Interior Space." Whitney Library of Design, New York, 1979.

4.0 Diffrient, N., A. Tilley and J. Bardagjy. Humanscale 4/5/6. The MIT Press, Cambridge Massachusetts, 1981.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SECURITY
VENTILATION
SHAPE
SUPERVISION
ACCESS
SATISFAC
CIRCU
ORIENTATION
AESTHETICS

WIRE MANAGEMENT SYSTEMS

INTRODUCTION

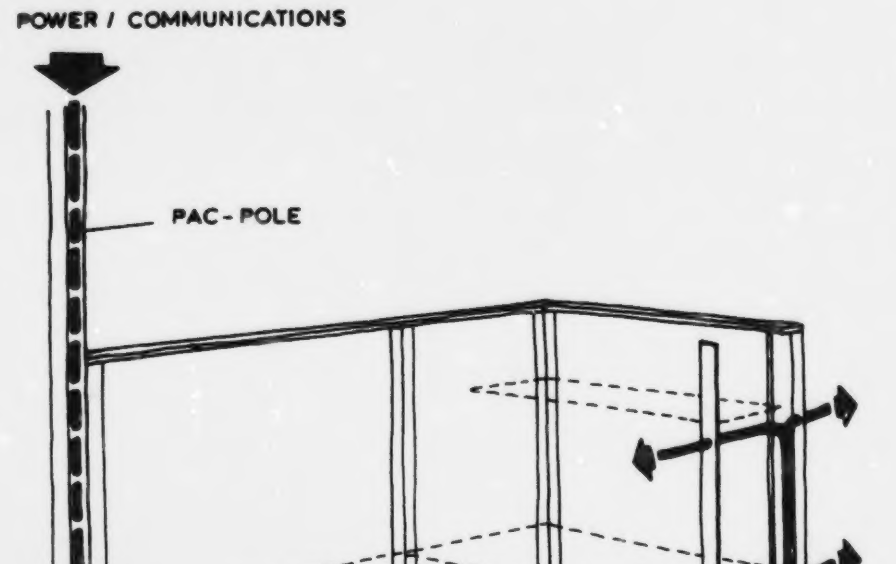
Where panel systems act as the overall furniture systems' spine, the wire management system is its central nervous system. The wire management system, contained in the panel system, must house and distribute services to each workstation from the architectural services outlet.

Wire management can be defined as the judicious use of existing technology in the provision of the necessary wire and cable to the electronic workstation plus the distribution of the electrical systems within the workstation.

The amount of wiring for the computer network systems within an office area have peaked and the equipment being developed today for data will be smaller and will require a smaller physical size of wiring to be provided.

The problems associated with distribution of the electrical systems within the electronic office include the following:

1. Accessibility of the wireway.
2. Capacity of the wiring space.
3. Ease of installation and relocation of outlets.
4. Separation and designation of "standard and computer grade" circuits.
5. Method of feeding into the wireway for the wire management system.
6. Method of distribution within the panels and system.
7. Allowable capacity for standard and computer circuits.


POWER / COMMUNICATIONS
PAC-POLE
REMOVABLE BASE COVER AND SIDE COVER FOR ACCESSIBILITY OF THE WIREWAY
POWER

WIRE MANAGEMENT

The purpose of the wireway systems within the panels is to provide:

1. An area within which the necessary wires can be installed for both standard and computer circuits,
2. A safe and satisfactory method of feeding from the wireway management systems to the equipment within the electronic office, and
3. Future capacity and capability of the panel system to accommodate the increasing use of electronic equipment.
4. A safe and satisfactory method of connecting panel systems to building systems for power/communication wire management.

Prior to installation of the wire management systems, detail drawings should be prepared by the electrical consultant indicating types and numbers of outlets required to accommodate equipment proposed for various systems. Maintaining the professional design approach, a task survey involving the owner, designer and manufacturer of the intended panel system is necessary to assess the availability of power and its method of distribution.

GENERAL REQUIREMENTS

1.0 The wire management systems shall be CSA certified and provided in accordance with the Canadian Electrical Code, the regulations of the Provincial Government, and those of the local inspection department. Wiring shall be installed concealed, shall be safely mounted and flexible.

(PRODUCT SPECIFICATION)

2.0 The responsibility for the supply and installation of the wire management systems shall be the responsibility of the panel supplier. The initial installation shall be done in coordination with the on-site electrical contractor and where required by Code or Union, this electrical contractor shall be utilized. Changes to the wire management systems after installation shall be done by qualified personnel in accordance with local regulations and requirements.

(PRODUCT SPECIFICATION)

3.0 All panel systems be capable of accepting electrical components which can be fitted in the field to provide wire management capabilities, as required, in the electronic office.

(VISUAL SPECIFICATION)

4.0 "As-Installed" set of sepias shall be turned over to the owner after completion of the installation. These "As-Installed" drawings shall indicate exactly the location of all outlets for power, telephone and data systems. Power circuits shall be identified as to the electrical panel and circuit number and as to whether the circuit is "standard" or "computer".

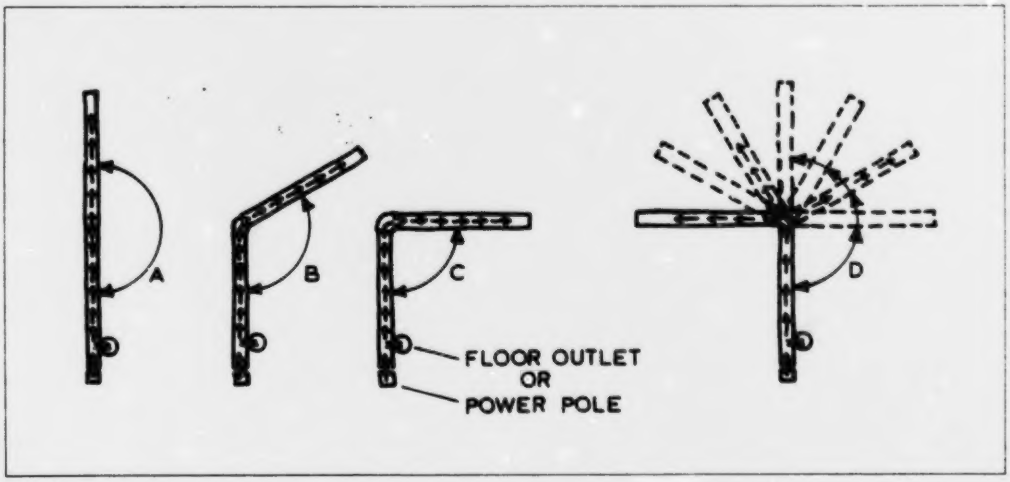
(VISUAL INSPECTION)

5.0 The wire management system when installed shall be an integrated and coordinated part of the panel, and shall be securely and safely installed. Surplus length of wire for the work surface equipment may be neatly coiled and attached to underside of work surface, i.e. by means of self-adhesive wire clips.

(VISUAL INSPECTION)

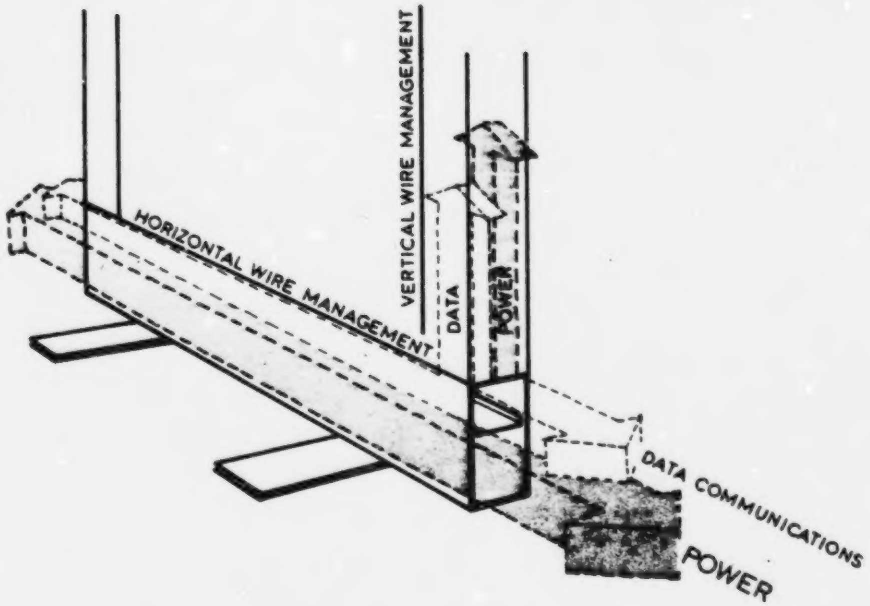
6.0 The wire management system shall be designed to allow the electrical panels to be configured in a variety of plans preferably in an infinitely variable manner.

(PRODUCT INFORMATION)



7.0 The wire management system must provide, at least, two discrete wiring spaces within vertical and horizontal plenums, to accommodate low tension and power conductors.

(PRODUCT SPECIFICATION)


VERTICAL WIRE MANAGEMENT
HORIZONTAL WIRE MANAGEMENT
DATA
POWER
DATA COMMUNICATIONS
POWER

DISCRETE SPACES FOR LOW TENSION AND POWER CONDUCTORS

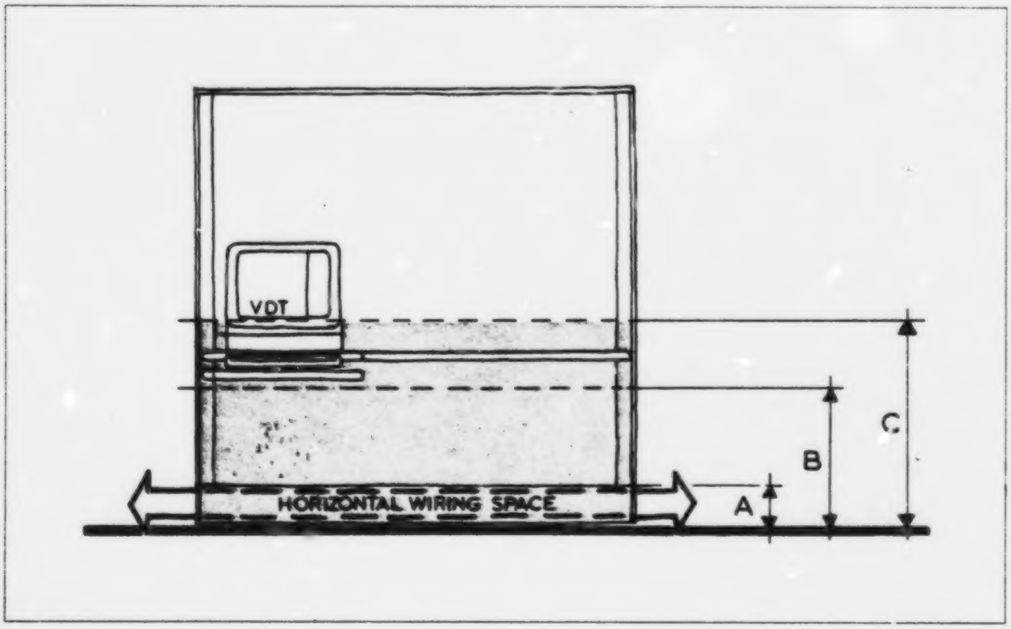
8.0 The horizontal wiring space (150 mm min.) shall be located within the panel system below the level of 550 mm (22 in.) from the floor to allow access to all wiring outlets. If excess wire storage for the work surface equipment is required within the panel, the maximum wiring space height shall not exceed 900 mm (35 in.) in height. Zero reference shall be the floor.

CRITERIA: Cross-sectional Area = 900mm^2

Minimum vertical dimension = 150mm or capacity for:
- 3 standard circuits
- 3 computer circuits
- 5 25-pair and 6 twin coax cables

A > 150mm
B = 550mm
C = 900mm

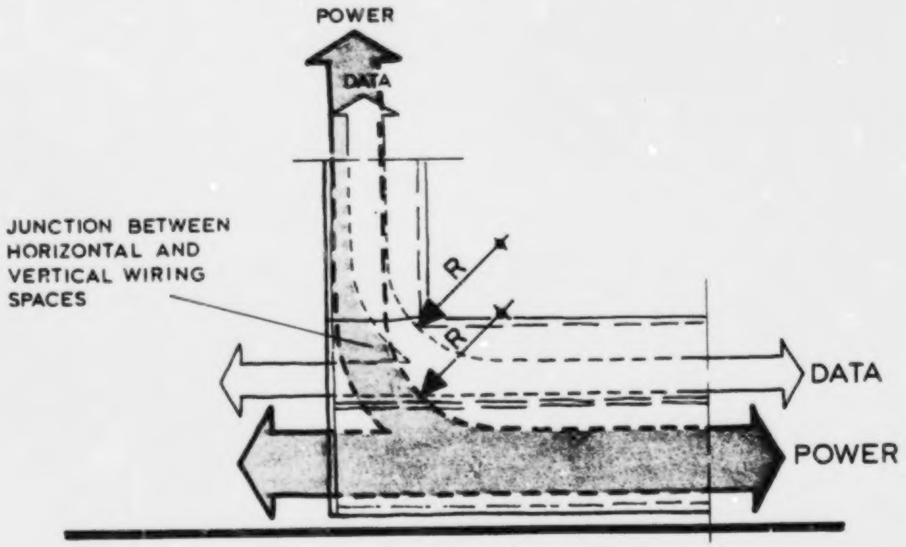
(PRODUCT MEASUREMENT)



9.0 Vertical wiring space and power pole feed from ceiling shall allow separately 1250 mm^2 for low tension wiring and an area large enough to allow a 9-wire cable and connector to be easily gravity fed from the top of panel to horizontal wiring space when the remainder of the conductors specified in Requirement 8.0 are already installed.

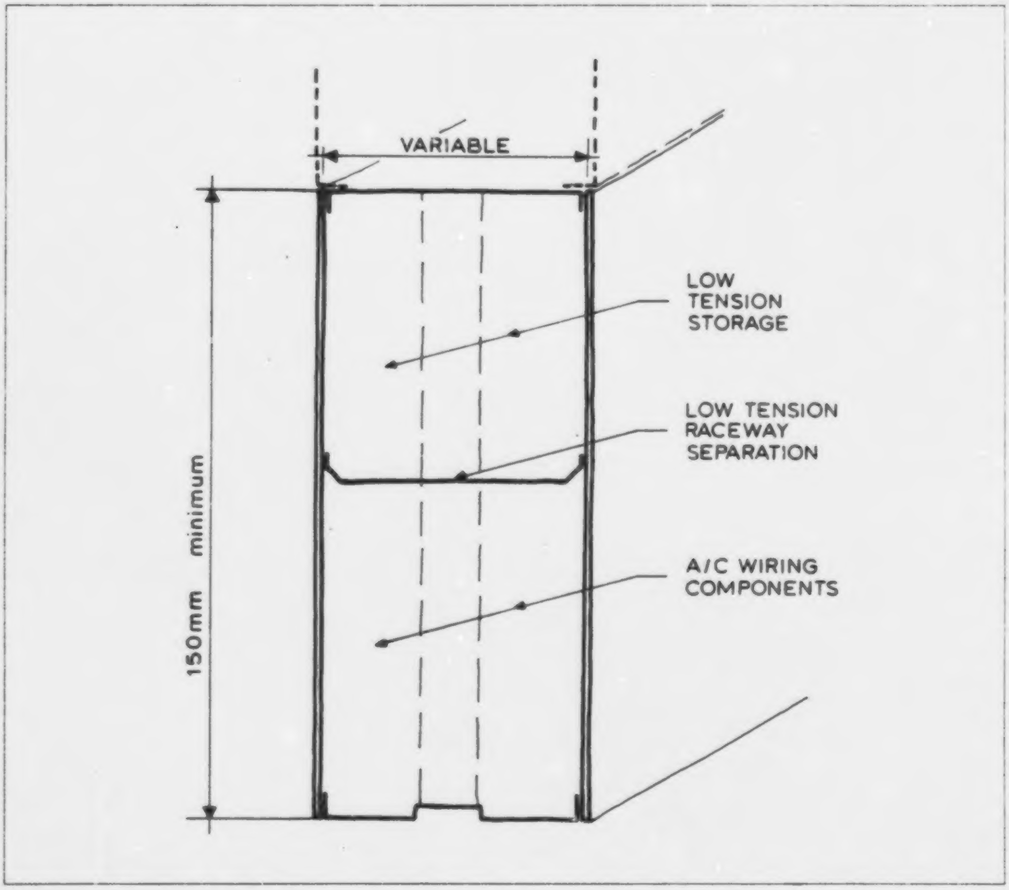
CRITERION: Sharp corners on the inner edge of junction between the vertical and horizontal are not acceptable. Connections shall allow for minimum bending radius (R) of six times cable diameter.

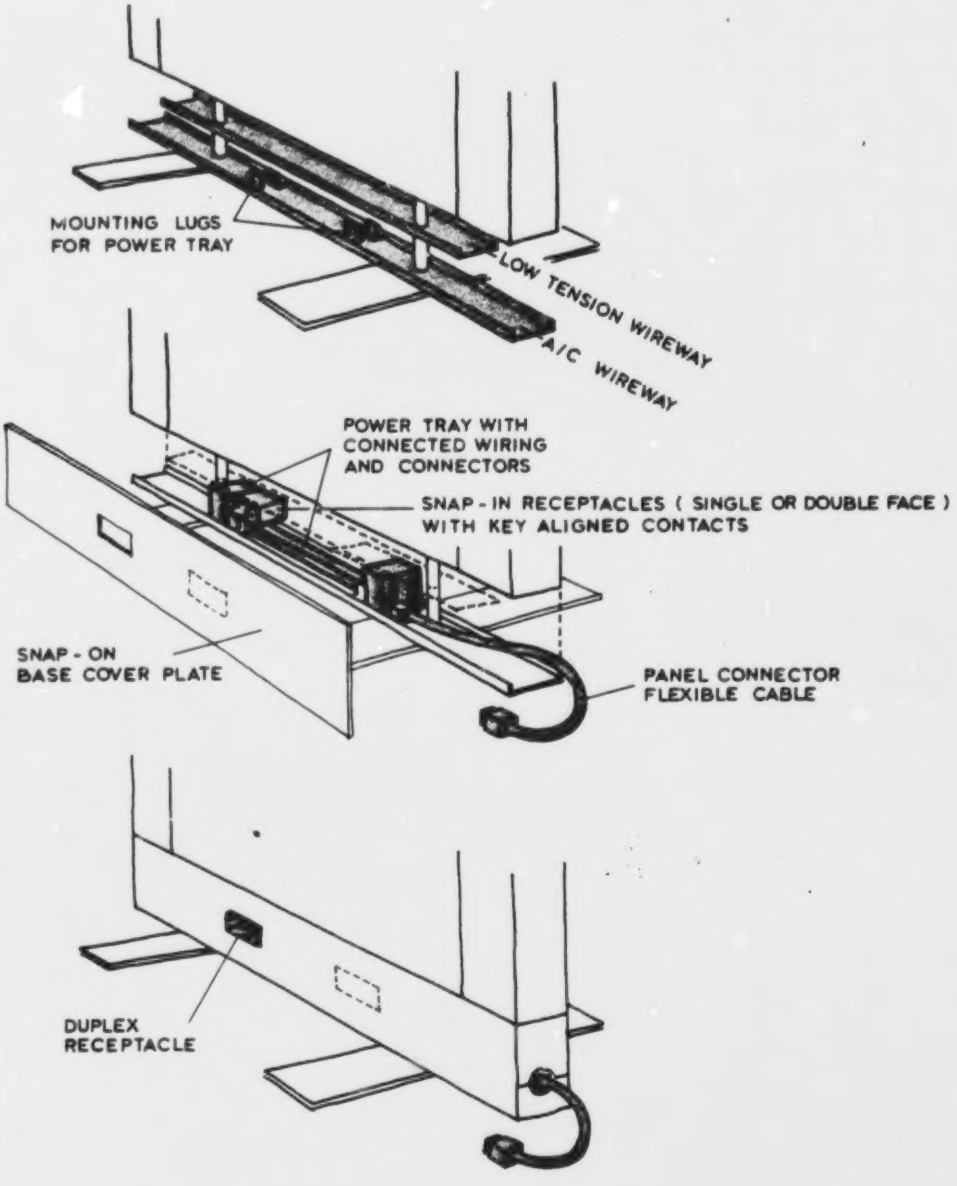
(PRODUCT SPECIFICATION)


POWER
DATA
JUNCTION BETWEEN HORIZONTAL AND VERTICAL WIRING SPACES
R
R
DATA
POWER

10.0 The low tension wiring space shall allow space for 12 data coaxial cable and 6 "logic 10" (25 pairs) communication wires with a total cross-sectional area of 4000 mm^2. The relationship of the low tension and AC wiring space is shown in the diagram. The separation between the wiring spaces shall be metal and preferably shall have turned up edges as indicated to assist and control the installation of the low tension wires and shall have a positive ground connection to the spaceway.

(PRODUCT MEASUREMENT)


VARIABLE
150mm minimum
LOW
TENSION
STORAGE
LOW TENSION
RACEWAY
SEPARATION
A/C WIRING
COMPONENTS



MOUNTING LUGS
FOR POWER TRAY
LOW TENSION WIREWAY
A/C WIREWAY
POWER TRAY WITH
CONNECTED WIRING
AND CONNECTORS
SNAP - IN RECEPTACLES (SINGLE OR DOUBLE FACE)
WITH KEY ALIGNED CONTACTS
SNAP - ON
BASE COVER PLATE
PANEL CONNECTOR
FLEXIBLE CABLE
DUPLEX
RECEPTACLE

11.0/12.0/13.0 ACCESSIBILITY TO ELECTRICAL AND COMMUNICATION SUPPLY

11.0 The system must provide clear unobstructed access to all raceways to lay-in or strip wiring without threading or use of fishing wire.

(WIRE INSPECTION)

12.0 All electrical components (power trays, connectors, receptacles, pass-throughs, etc.) shall be interchangeable and retrofittable with all panel types of the same width to accommodate the configuration and changing power requirements within the office.

Components shall also be of the plug-in or snap-in type such that installation or removal of components can take place without disturbing other wiring or without requiring the services of an electrician to assemble/dissassemble components. Standard electrical products are acceptable provided this plug-in feature is maintained.

(PRODUCT LITERATURE EVALUATION)

13.0 The panel system shall provide removable faceplates for the AC and low tension wiring spaces which shall allow access from both sides of the panel and provide clear unobstructed access to the wiring spaces. Each faceplate shall be provided with cut-outs to accept the particular receptacle for the AC section and knockouts for the extension of the low tension wiring. All knockouts performed or cut on the job shall be provided with nonconducting grommets. Removal and installation of faceplates shall not require tools.

(VISUAL INSPECTION)

14.0 A tie or tape system shall be utilized for installation of the low tension wires to prevent spilling into the AC wiring space or interfering with the coverplate and connectors. Fastening methods for armoured cable shall conform to CSA.

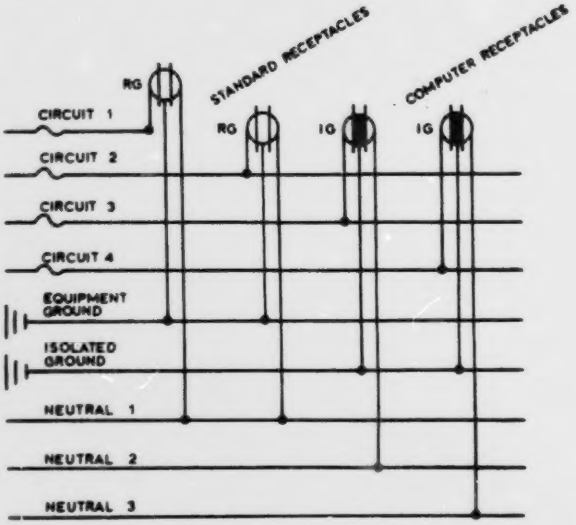
(PRODUCT SPECIFICATION)

15.0 All wiring for panel installed task and ambient lighting shall be concealed and managed in vertical or horizontal raceways, at vertical panel joints.

(PRODUCT LITERATURE EVALUATION)

16.0 Computer receptacles shall be of the isolated ground type (orange - colour). Their grounding shall be by means of dedicated ground wires tied to a dedicated ground system. Computer receptacles shall have separate neutrals for each circuit. Standard receptacles shall use regular ground and may employ a common neutral.

(PRODUCT SUPERVISION/EVALUATION)


STANDARD RECEPTACLES
COMPUTER RECEPTACLES
RG
RG
IG
IG
CIRCUIT 1
CIRCUIT 2
CIRCUIT 3
CIRCUIT 4
EQUIPMENT GROUND
ISOLATED GROUND
NEUTRAL 1
NEUTRAL 2
NEUTRAL 3

17.0 Each component of the wire management system shall be labelled by both a part number and description of its function and size where applicable, i.e. power tray, 48 in.; passthrough cable, 60 in. and AC outlets labelled with 10 mm sans serif alphanumeric characters indicating "Computer" or "Standard" powered receptacles.

(PRODUCT MEASUREMENT)

18.0 Wiring space body and separator shall be constructed of metal.

(PRODUCT SPECIFICATION)

19.0 All terminal points (connector) and exposed AC wiring shall be colour coded throughout the panel system with the same colour applying to the same phase of neutral and ground throughout. Colour coding to be in accordance with industry standards and to differentiate computer circuits, standard circuits, neutral wires and ground wires.

(VISUAL INSPECTION)

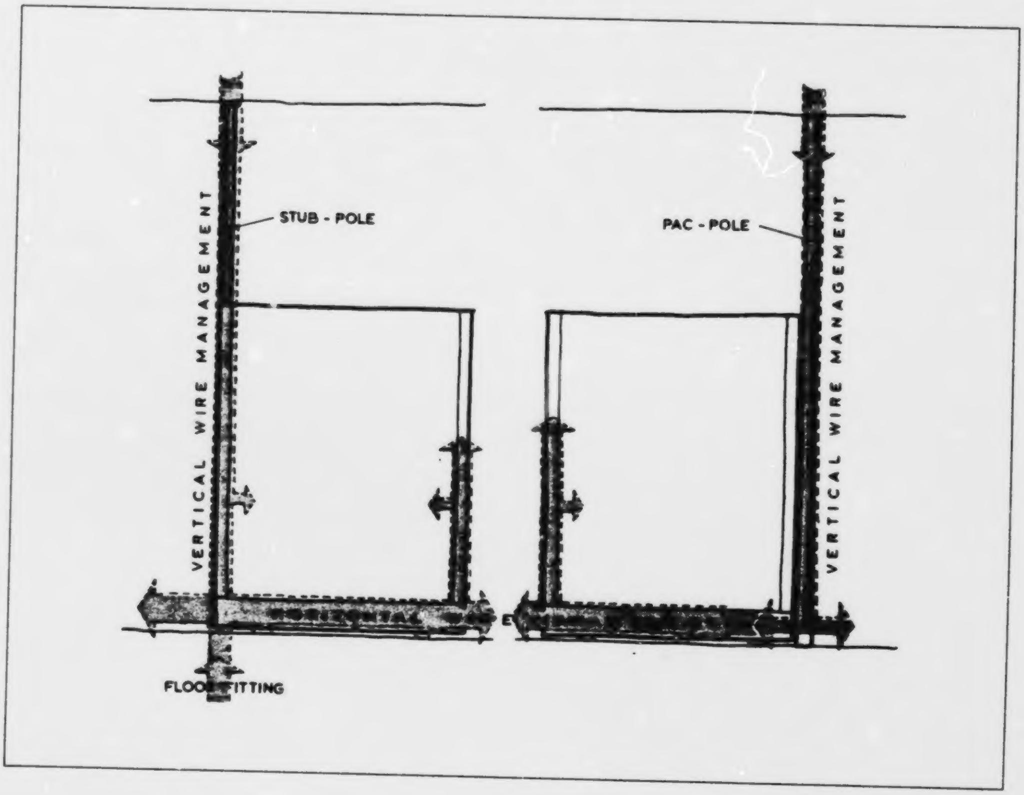
20.0 All components shall be capable of connecting from one panel to another regardless of configuration.

(PRODUCT SPECIFICATION)

PANEL IN-FEED

21.0 The wire management system shall be capable of accepting power from both sides and ends into coverplate for the main horizontal wiring spaces. Vertical infeed power from ceiling must be accepted via vertical wiring spaces internally connected to the horizontal wiring space.

(VISUAL INSPECTION)


VERTICAL WIRE MANAGEMENT
STUB - POLE
PAC - POLE
VERTICAL WIRE MANAGEMENT
HORIZONTAL
FLOOR FITTING

22.0 Panel in-feed from the ceiling must securely connect from the vertical wiring space of the panel through power poles. These power poles should be provided with necessary parts to secure the top of the pole to the ceiling and complete with ceiling bezels. Length of the power poles should be such that they penetrate the ceiling approximately 152 mm above the top of the suspended ceiling. Power poles shall be CSA approved.

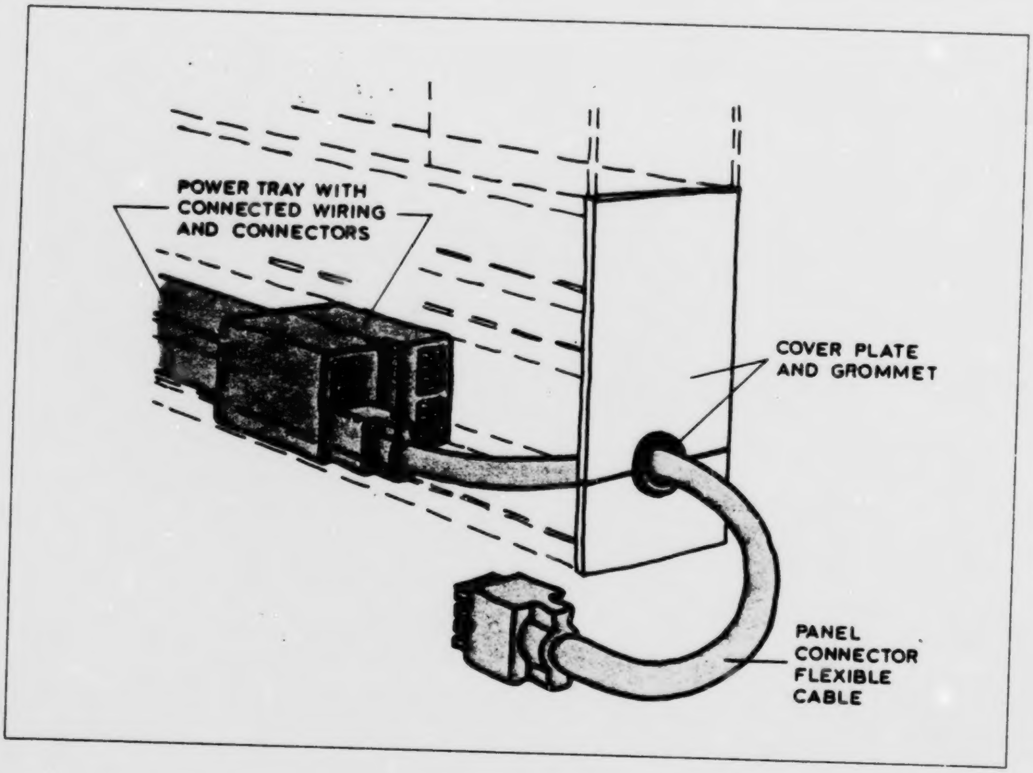
(PRODUCT SPECIFICATION)

23.0 All panel in-feed cables for both ceiling entry or floor entry shall have a minimum length of 1828 mm; floor power cables to be armoured cable Type BX or BXL.

(PRODUCT SPECIFICATION)

24.0 All in-feed cables shall have factory installed molded case connectors or standard electrical products compatible with the electrical components of the panel system, for connection by means of exposed conductors at the panel in-feed point for hard wire connection to the electrical incoming feed. Where electrical cables or low tension cables enter the faceplate of the wiring space system, proper grommets should be provided.

(PRODUCT SPECIFICATION)


POWER TRAY WITH CONNECTED WIRING AND CONNECTORS
COVER PLATE AND GROMMET
PANEL CONNECTOR FLEXIBLE CABLE

POWERED PANELS

25.0 Panels shall provide two 120 volt, 15 amp computer grade circuits and two 120 volt, 15 amp standard circuits. Equipment ground will apply to the standard circuit only and a separate ground shall be provided for the computer grade circuits. Separate neutrals are to be provided for the computer grade circuits. Standard circuits may use a common neutral.

(PRODUCT SPECIFICATION)

26.0 Powered end panels shall provide for direct electrical connection to adjacent panels and connectors shall have a mechanical locking and unlocking device.

(PRODUCT SPECIFICATION)

27.0 Computer circuit receptacles shall be orange in colour of the isolated ground type and marked "Computer Outlet Only" with circuit designations. All receptacles shall be of the CSA 5-15R configuration.

(PRODUCT SPECIFICATION)

28.0 All receptacles shall have a minimum rating of 120 volt, 15 amp. The faceplate for the wiring space systems for all panels less than 914 mm shall have a preformed opening when not in use. Faceplates for panels 914 mm and wider shall have two preformed openings for duplex receptacles with self-storing cover plate. Faceplates for both sides of wiring spaces will be so equipped with the exception of curved panels which will only function as wiring space for connecting to the next panel. Coverplate openings shall pass the standard CSA mandrel test with the receptacles in place.

(PRODUCT SPECIFICATION)

29.0 All panels except the curved units shall be capable of accepting power harness or power components for distribution of two computer circuits and two standard circuits.

(PRODUCT SPECIFICATION)

ELECTRICAL CONNECTOR

30.0 The electrical connectors providing power to the panels shall be of such design that disconnection of the connector will render all contacts safe and non-conductive of electrical current.

Where all circuits are contained in the same cable/component system, a minimum 9-pin connector shall be used. Where circuits are split into more than one system, they shall be split on a computer grade/standard circuit basis and connectors of the two systems shall not be interchangeable.

(PRODUCT SPECIFICATION)

ACCESS

31.0 The panel coverplate, fillers and end caps are to be designed for snap-in mounting but secure enough that accidental bumping or kicking shall not dislodge them.

(PRODUCT SPECIFICATION)

32.0 The low tension wiring space, vertical and horizontal, is to be accessible to laying-in or removing wires without the "fishing" or "threading".

(PRODUCT SPECIFICATION)

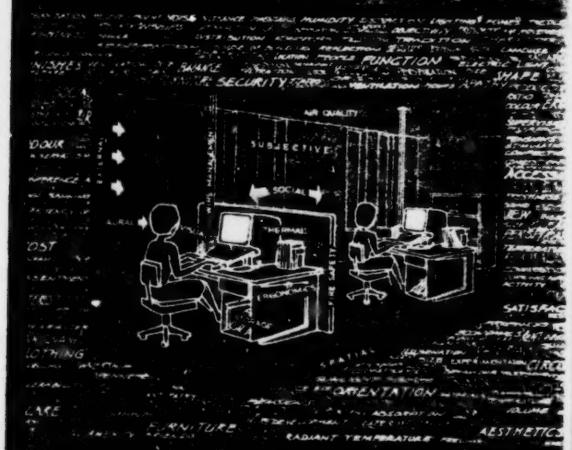
33.0 All work surfaces should be provided with grommeted access holes through which the power and low tension cables can be brought from the wire spaces to the particular equipment. Excess of wire can be coiled and fastened to the underside of the work surface. Where access points are above work surfaces, provisions for excess office equipment wire storage shall be made available.

(PRODUCT SPECIFICATION AND IDENTIFICATION)

REFERENCES

Canadian Standards Association "Canadian Electrical Code, Part I" CSA 22.1.

ELECTRONIC OFFICE DESIGN GUIDE


NOISE
HUMIDITY
LIGHTING
DISTRIBUTION
REFLECTION
FUNCTION
BALANCE
SECURITY
VENTILATION
SHAPE
AIR QUALITY
SUBJECTIVE
SOCIAL
AURAL
THERMAL
ERGONOMICS
FIRE SAFETY
ODOUR
COST
CLOTHING
ACCESS
SATISFACTION
SPATIAL
ILLUMINATION
ORIENTATION
CIRC
GLARE
FURNITURE
RADIANT TEMPERATURE
AESTHETICS

SEATING

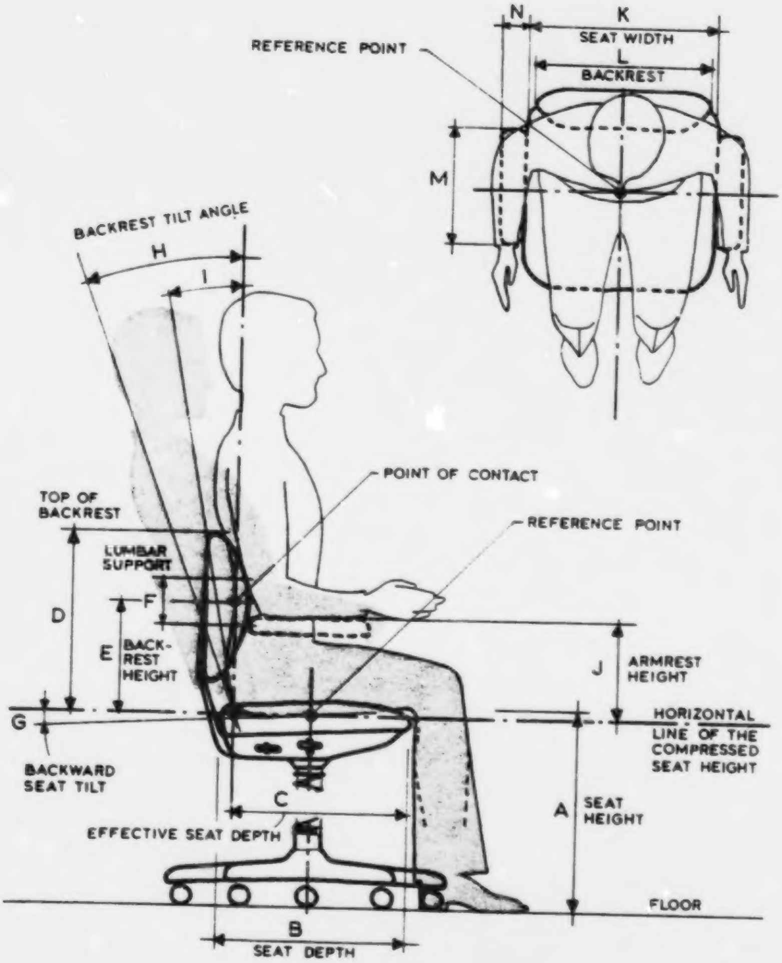
INTRODUCTION

The impact of information technology on seating is quite significant. While the anatomical characteristics of human beings are varied, they have remained relatively constant, but the task requirements when using a computer terminal as well as the physical link to the equipment and documents have revealed seating inadequacies which can substantially affect user performance and efficiency.

Despite the apparent reduction in the costs of equipment with each generation of computers, the costs of implementing and using information technology (workstations, work design, communication) has been increasing, more than any savings on equipment costs. Moreover, recent findings by behavioural scientists have clearly illustrated the long term economic advantages of improving working conditions for employees with respect to user performance and efficiency levels.

The office chair can best be regarded as an extension of the human body where the seat, base and casters are analogous to one's legs and pelvis, providing general support to the body. The armrests and backrests provide additional support to the spinal column, and the upper body support. In this approach, defining design criteria involves asking what body support is necessary and what characteristics can provide such support comfortably. This approach also provides a basis for understanding and defining requirements of the physically disabled who are taking up employment opportunities in computer related areas in increasing numbers.

The objective is to define design criteria which promote user safety, well being and comfort while optimizing user performance and effectiveness.


N
K
SEAT WIDTH
L
BACKREST
REFERENCE POINT
M
BACKREST TILT ANGLE
H
I
POINT OF CONTACT
REFERENCE POINT
TOP OF BACKREST
LUMBAR SUPPORT
D
F
E
BACK-REST HEIGHT
J
ARMREST HEIGHT
G
HORIZONTAL LINE OF THE COMPRESSED SEAT HEIGHT
BACKWARD SEAT TILT
C
EFFECTIVE SEAT DEPTH
A
SEAT HEIGHT
FLOOR
B
SEAT DEPTH

VDT OPERATOR CHAIR CRITERIA

1.0 GENERAL

To accommodate the tasks of the electronic office workstation and to fit the anatomy of the user, the following combination of functional and ergonomic design criteria for the chair have to be met.

CRITERIA:

A. Seat height = 360 mm - 480 mm, minimum range

B. Seat depth ≥ 400 mm.

C. Effective seat depth = Range between 380 mm and 420 mm

D. Top of backrest (above horizontal line of the compressed seat height) = 300 mm to 330 mm.

E. Backrest height (above horizontal line of the compressed seat height) ≧ 400 mm

F. Lumber support ≧ 150 mm

G. Backward seat tilt = 0° to 5° if foward seat tilt not adjustable. Forward seat tilt (optional) 3°.

H. Backrest tilt angle (free) = 18°

I. Backrest tilt angle (lock) range = 2° to 10°

J. Armrest height (above horizontal line of compressed seat height) range = 220 mm to 270 mm

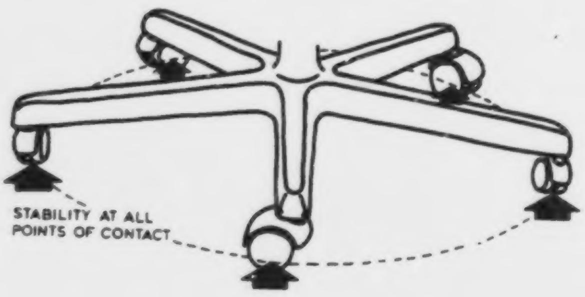
K. Seat width ≧ 400 mm

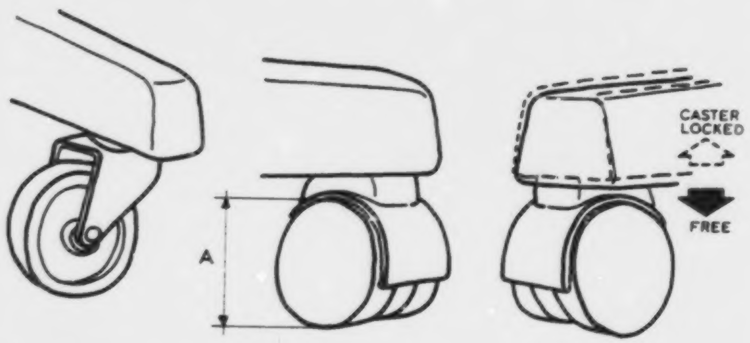
L. Backrest width = 300 mm at lumbar area

M. Armrest length = range 150 mm to 220 mm.

N. Armrest width ≧ 50 mm

(PRODUCT SPECIFICATION/MEASUREMENT)

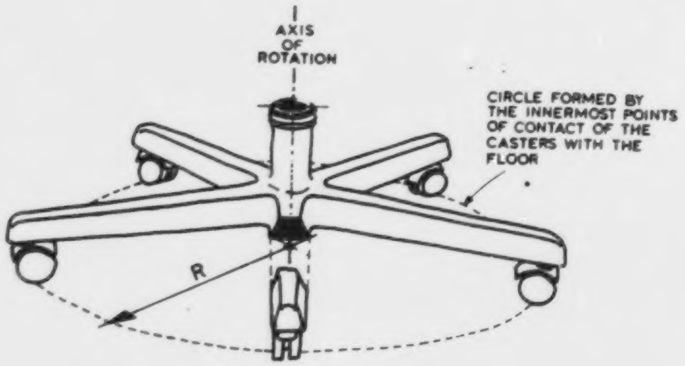

STABILITY AT ALL POINTS OF CONTACT


CASTER LOCKED
FREE
A

HARD WHEEL

DUAL WHEEL
NON - SLIP MATERIAL

DUAL WHEEL
DEVICE SELF LOCKING WHEN NOT BE SEATED


AXIS OF ROTATION
CIRCLE FORMED BY THE INNERMOST POINTS OF CONTACT OF THE CASTERS WITH THE FLOOR
R

2.0/3.0/4.0/5.0 CHAIR BASES AND CASTERS

CHAIR BASES AND CASTERS

2.0 The chair base shall comprise 5 blades with swivel caster (360°) ensuring stability at all points of contact while not obstructing the feet of the user when rising or sitting.

(PRODUCT INSPECTION)

3.0 The casters shall allow the chair to be easily moved on all floor finishes (carpet and tile). All bases shall be rounded and projections eliminated.

CRITERION: Range of Diameter (A) of Swivel Caster:
$60 \text{ mm} < A < 75 \text{ mm}$

(PRODUCT EVALUATION)

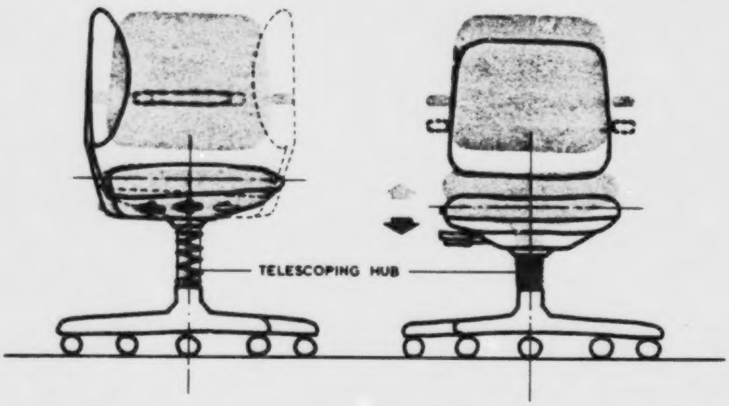
4.0 The bases shall be designed not to roll unintentionally on any level surface. All casters shall be designed of non-slip durable material with sealed bearings to prevent debris from entering the bearing tracks.

CRITERIA:	Recommendation:	Dual wheel for all floor finishes
	Optional:	Dual wheel with self locking device.

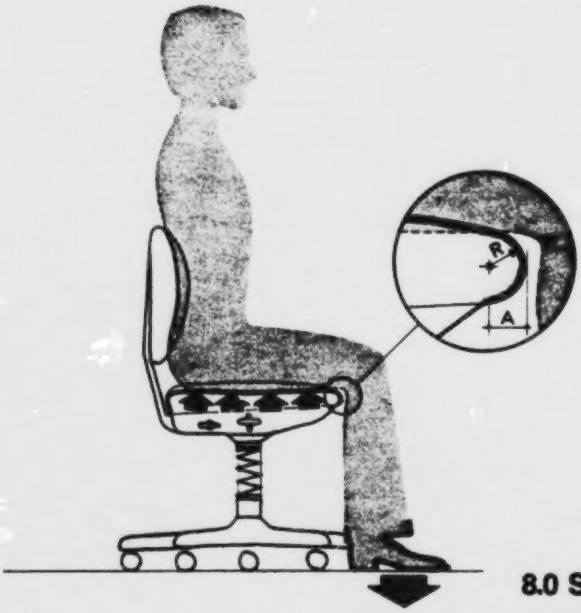
(PRODUCT SPECIFICATION)

5.0 The radius of the circle (R) formed by the innermost points of contact of the casters with the floor chair shall not be less than 190 mm and not greater than the maximum horizontal seat dimension (including armrests, if present).

(PRODUCT MEASUREMENT)


TELESCOPING HUB

6.0/7.0 SEAT ADJUSTABILITY REQUIREMENTS



8.0 SEAT CONTOURING

SEATS

6.0 The telescoping hub shall be of a material that shall not loose its shape or become deformed at any point within its range.

(VISUAL INSPECTION)

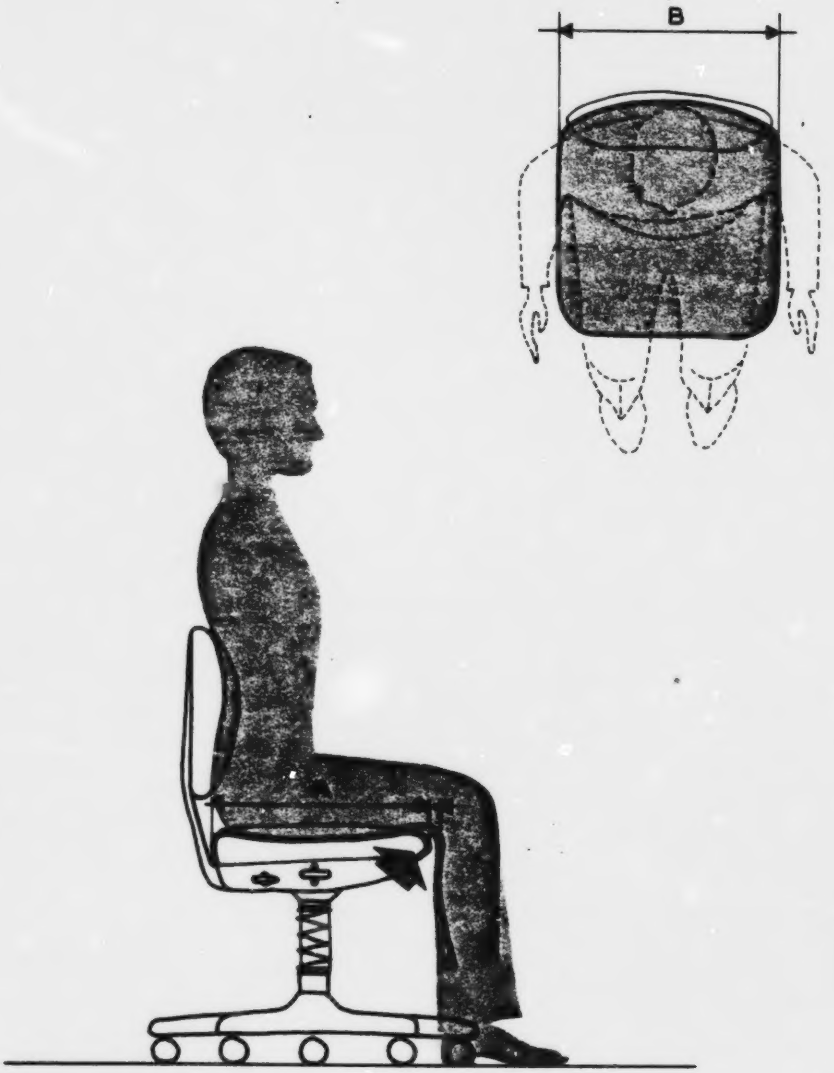
7.0 The seat shall rotate independently on the base and shall be adjustable in height.

(PRODUCT INSPECTION)

8.0 All seats shall be designed with the cascading leading edge to minimize, potential pressure at the anterior aspect of the knee and permit the users to place their feet on the ground. The seats shall also have firm surfaces contoured to conform to buttocks and thighs in order to distribute the weight evenly for long periods.

CRITERION: Radius $R \geq 50$ mm
$A = 50$ mm

(PRODUCT EVALUATION)



9.0 SEAT SIZE REQUIREMENTS

9.0 The seat size shall accommodate the 5th to 95th percentile user.

CRITERIA: Effective seat depth: 360 mm < A < 420 mm
Effective seat width: B = 400 mm.

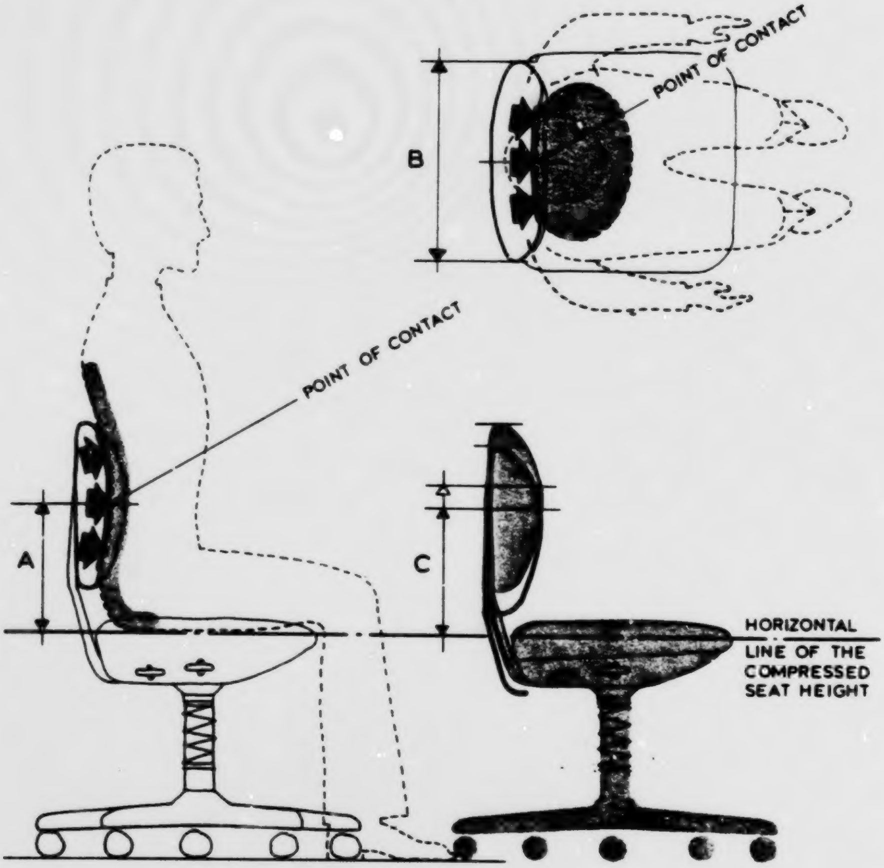
ARMRESTS

10.0 Armrests shall be designed to provide support to the elbow and forearm, and must be stable for assisting in egress and sitting.

(PRODUCT INSPECTION, ANSI 1977)

11.0 Armrests shall be designed to be field demountable with a minimum of tools by unskilled labour, and when detached neither the removed part nor the chair shall expose unsafe sharp edges, burrs, etc.

(PRODUCT INSPECTION)


POINT OF CONTACT
B
POINT OF CONTACT
A
C
HORIZONTAL
LINE OF THE
COMPRESSED
SEAT HEIGHT

12.0/13.0/14.0 BACK RESTS

BACKREST

12.0 The backrest shall provide firm support and shall conform to the curvature of the back vertically and laterally.

(VISUAL INSPECTION)

13.0 The height of backrest (A) can be fixed or adjustable.

CRITERIA: Fixed: A = 240 mm

Adjustable: 220 m < A < 280 mm
C = 220 mm to 280 mm

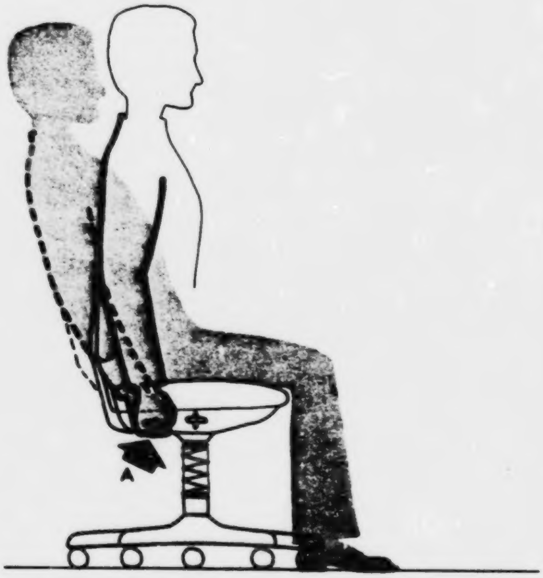
(Mechanism can be mechanical or pneumatic)

(PRODUCT MEASUREMENT)

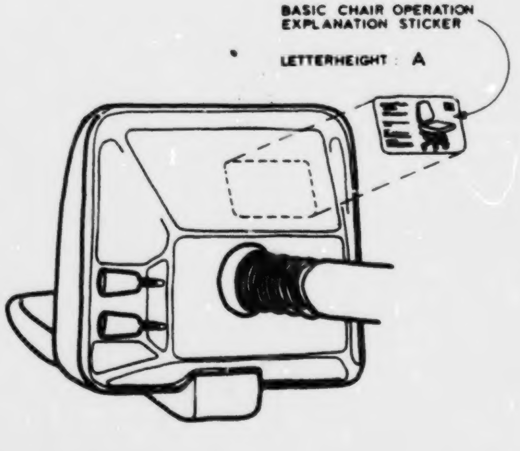
14.0 Effective backrest width (B) shall accommodate 5th to 95th percentile user, regardless of chair type. Where adjustable, the backrest shall be capable of being locked into position when seated. Back angle may be locked, as an option.

CRITERION: B = 350 mm (minimum)

(PRODUCT MEASUREMENT)



15.0 ADJUSTMENT CONTROLS


BASIC CHAIR OPERATION
EXPLANATION STICKER
LETTERHEIGHT : A

16.0 SEAT SHELL UNDERSIDE VIEW

ADJUSTMENT CONTROLS

15.0 Controls for all adjustments shall be readily accessible from the seated position and be adapted to the strength and handsize of users. Controls shall be fail safe and require positive action to operate. Operation shall be smooth throughout range of operation.

CRITERION: Actuating force: $40\ \mathrm{N} < A < 100\ \mathrm{N}$

(PRODUCT MEASUREMENT, ANSI 1977)

16.0 The manufacturer shall include a basic chair operation explanation sticker permanently secured to the underside of the seat shell. The shell constructed of molded textured plastic or metal shall completely enclose all mechanisms.

CRITERION: Letter height: $A \leq 6.0$ mm

(VISUAL INSPECTION)

FINISHES

17.0 Fabric shall bee free from distortion, stretched equally in all directions and have all edges concealed to prevent fraying.

(PRODUCT EVALUATION)

18.0 Upholstery should not be unpleasant to the touch (slippery, itchy, cold) or permit build-up of perspiration.

(PRODUCT EVALUATION)

19.0 Upholstery shall be a permeable fabric of suitable durability and texture.

REFERENCES

1. Croney, J. "Anthropometry For Designers," Revised Edition. 1981, New York: Van Norstrand.

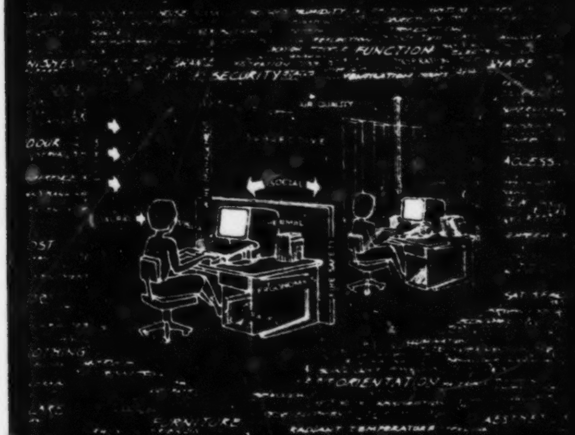
2. Clauser, C. et.al. "Anthropometric Source Book." A Handbook of Anthropometric Data, Reference Publication 1024, 1979, Science Technical Information Office.

3. Diffrient, N., Tilley, A., & Bardagjy, J. "Humanscale 1/2/3." 1979, Cambridge: The MIT Press.

4. McCormick, E.J. "Human Factors In Engineering and Design," 4th Ed. 1976, New York: McGraw Hill Book Company.

5. Panero, J., & Zelnik, M. "Human Dimension and Interior Space:" A Source Book of Design Reference Standards. 1979, London: Whitney Library of Design.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SHAPE
SECURITY
AIR QUALITY
ODOUR
ACCESS
SOCIAL
ORIENTATION
FURNITURE
RADIANT TEMPERATURE

MATERIALS AND CONSTRUCTION

INTRODUCTION

The workstation plays a important role within the context of the overall electronic office environment. It is ultimately the focus of activities - the *raison d' être* for the performance guidelines. Hence it must provide all the functional requirements. It must be capable of providing wire management, contribute positively to the lighting and acoustic environment, provide adequate storage and have integral adjustability to accommodate the variety of uses and users.

The workstation should be also stable and rigid when used independently or in a group or, when used in conjunction with a complimentary panel system. The design should also permit the work station to be "knockdown" construction, easily assembled and simple to reconfigure.

The objective of this section is to evaluate the materials and construction of the assembled workstation under simulated working conditions in terms of the structural and constructional qualities, and manufacturing and assembly techniques.

GENERAL REQUIREMENTS

1.0 The workstation shall be "knock-down" construction to facilitate packaging storage, shipping and warehousing.

(VISUAL INSPECTION)

2.0 When the workstation is disassembled, no component, when fully packaged, shall exceed the capabilities of two average strength office workers to carry.

CRITERION: Weight = 40Kg

(PRODUCT MEASUREMENT AND WEIGHT)

CONSTRUCTION REQUIREMENTS

3.0 All workstation componentry shall be fabricated and finished to specified tolerance levels for fit and assembly purposes.

CRITERION: ± 2.5 mm

(PRODUCT SPECIFICATION AND MEASUREMENT)

4.0 All workstation componentry shall be constructed of high quality materials conforming to established industry standards.

1. Wood Components
   a) All particle board shall conform to CSA 0115 and
   b) Quality standards of the Architectural Woodwork Manufacturers Association of Canada shall apply.
2. Metal Components
   a) All steel shall conform to CSA 940.21
   b) All welds shall be performed by welders approved by Canadian Welding Bureau under CSA W47.1

3. Plastic Components
   a) All laminates shall be Class 1, conforming to Can 3-A172-1978 (or latest edition).
   b) All plastic components shall be free from shard, rough edges (flash) and be ultra-violet light stable.

4. Fastenings
   a) All staples shall be corrosion resistant and have adequate strength and rigidity for the task.
   b) All wood used for splines shall be dimensionally compatible with main wood type.
   c) Glues shall be waterproof, high strength, and durable.

(PRODUCT SPECIFICATION)

STABILITY REQUIREMENTS

5.0 Horizontal Stiffness Test: The assembled workstation shall be loaded with a 30 Kg mass, acting on an area exceeding .03 m^2, and be subjected to a lateral force of 150N through a circular loading pad of 75 mm diameter, at the transverse centre line of the working edge of the table top.

CRITERIA: No fractures of any member or joint.

No loosening of joints.

No permanent deformation.

(BS4875: PART 2)

6.0 Horizontal Racking Test: The workstation, restrained at one end from horizontal movement and on rollers at the other end, shall be subjected to a horizontal load of 240N, applied at right angles to one longitudinal edge at the top and at a distance of 50 mm from the free end through a 75mm dia. pad. The cycling rate shall not exceed 15 cpm.

CRITERIA: No fractures of any member or joint.

No loosening of joints.

No permanent deformation.

(BS4875: PART 2)

7.0 Horizontal Static Load Test: A horizontal force of 800N shall be applied ten times through a circular 75mm diameter pad to the top along the longtudinal centre line at a rate not to exceed 15 cpm. Tests shall be repeated along the transverse centre line of the top, in two directions, with the appropriate change in the restraints and the direction of the axis of any rollers. The work station shall be statically loaded with 30Kg, acting on an area exceeding 0.03 m^2 for this test.

CRITERION: The workstation shall not overbalance.

(BS4875: PART 2)

8.0 Horizontal Fatigue Test: With the workstation restrained at all floor contact points and statically loaded with a 30Kg, acting on an area exceeding 0.03 m^2, a horizontal force of 150N shall be applied through a 75 mm diameter pad at the transverse centre of the working edge of the table top. The force shall be applied 100,000 times. The cycling rate shall not exceed 15 cpm.

CRITERIA: No joint fractures of any member or joint.

No loosening of joints.

No permanent deformation.

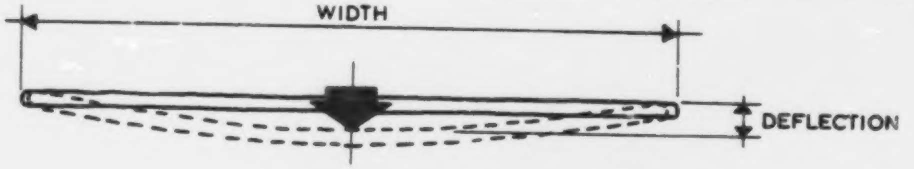
(BS4875: PART 2)

9.0 Vertical Stiffness Test: All work surfaces shall be designed for minimal deflection under 100 Kg load which shall be applied at any point along the edge of a work surface.

CRITERIA: Deflection 30 mm or

Deflection w/16 (whichever is smaller).

(BS4875: PART 2)

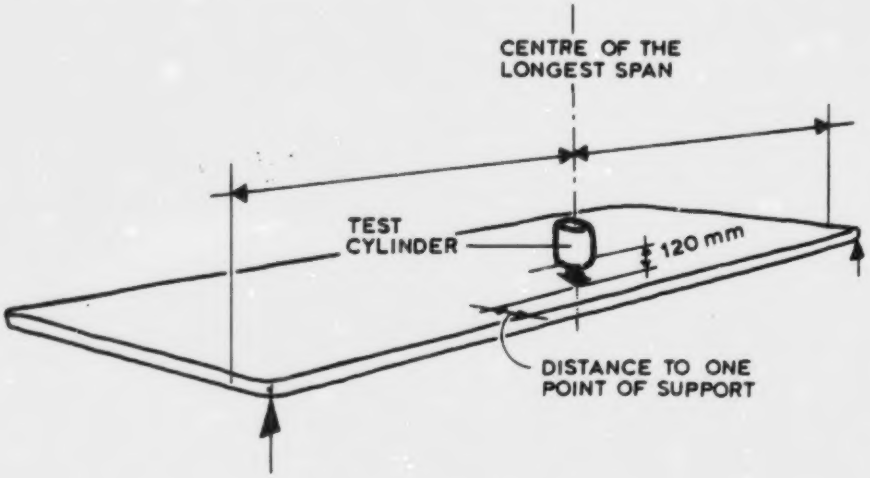


9.0 VERTICAL STIFFNESS TEST

10.0 Surface Impact Test: All work surfaces shall designed to withstand a dynamic impact load from of 3.0 kg. when a steel cylinder of 75 mm diameter with ends radiused to 15 mm and 77 mm long is dropped on its axis from a vertical height of 120 mm. The test shall be applied to the most rigid region of the surface as close as possible to a line of support of the surface being tested, and to the centre of the longest span.

CRITERION: No damage to surface.

(BS4875: PART 2)

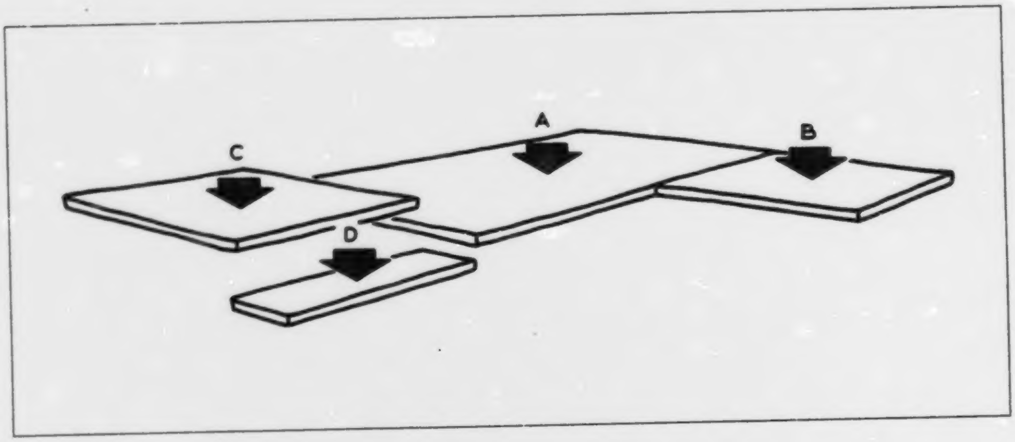

CENTRE OF THE LONGEST SPAN
TEST CYLINDER
120 mm
DISTANCE TO ONE POINT OF SUPPORT

10.0 SURFACE IMPACT TEST

11.0 Static Loading Test: All work surfaces shall be designed to withstand a vertical downwards force which shall be applied 10 times at a rate not exceeding 15 times per minute over an area of 100 mm x 100 mm anywhere on the top that is likely to cause failure. The test shall be repeated at all such positions.

CRITERIA:
A. 100 kg. Primary work surfaces
B. 100 kg. Secondary work surfaces
C. 50 kg. VDT Work surfaces
D. 50 kg. Keyboard work surfaces

(BS4875: PART 2)



DIMENSIONAL STABILITY REQUIREMENTS

12.0 All work surfaces of wood construction, or wood core with laminate shall not distort, crack or fail due to variations of 8% to 12% in relative humidity levels at 18°C.

(BSI4875: PART 2)

REFERENCES

1.0 British Standard Institution "Specification for Strength and Stability of Domestic and Contract Furniture." BSI 4875: Part 2: 1977

2.0 American National Standard Institute "American National Standard for Office Furnishings - Desk Products - Tests" ANSI/BIFMA 1983

3.0 Canadian Standards Association "Hardwood and Decorative Plywood" CSA-0115 - 1982 Rexdale, Ontario

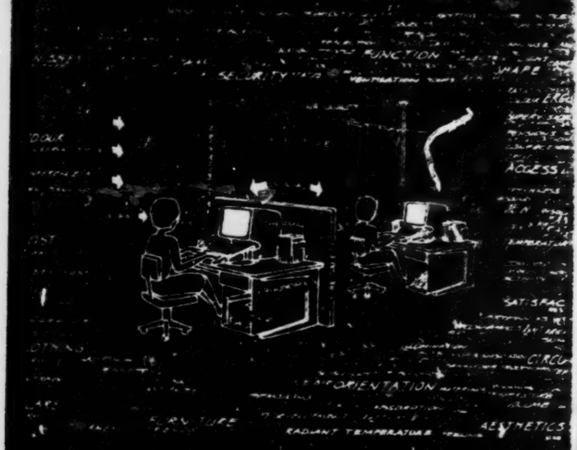
4.0 Canadian Standards Association "Certification of Companies for Fusion Welding of Steel Structures" W97.1 - 1983 Rexdale, Ontario

5.0 Canadian Standards Association "High Pressure Paper Base Decorative Laminates" Can 3-A172 - M79 Rexdale, Ontario

PRODUCT LITERATURE REVIEW (1984)

Acoustical Screens Corporation
Alex Stewart Design Inc.
All-Steel Canada, Ltd.
Ambiant
Artec
Beeiner & Thomas
Beautiline Systems Limited
Business Furniture Systems
Conweed Corporation
Croydon Furniture Systems Inc. (Metrix)
Dunbar
Dynamic Custom Equipment Limited
Egan Visual Inc.
Eagle Computer Furniture Systems
EBCO Industries
EBI
Formac
G.F. Furniture Systems
Gispen & Staaimeubel bV
Global Upholstery Company Ltd.
Karl Gutmann Inc.
Hammond Manufacturing Company Ltd.
Harter Corporation
Haworth Inc.
E.F. Hauserman Company
Herman Miller Inc.
Howe Furniture Corporation
Intergraph Corporation
Inotec Systems Inc.
J.G. Furniture Systems
Kinetics Furniture
Knoll International
Kombi Office Automation Systems
Krug
Lehigh - Leopold LBF
Litton Business Systems Inc.
Lowe - Martin Company Inc.
Metalstand
Neilwin
Nightingale Interloc Limited
NKR Environments Limited
Optimum Management Inc.
O.S.C. Partitions Limited
Pace Business Interiors
Precision Manufacturing Inc.
Proform Furniture Industries Limited
Ram Partitions
Reff Incorporated
Sico Inc.
Steelcase Inc.
Ste-Marie & Laurent Inc.
Storwal International Inc.
Stow/Davis
Sunar
Superior Steel Desk Mfg.
Systems Furniture Company
System B/8
Teknion Furniture Systems Inc.
Westinghouse Corporation
Wright Line of Canada
Xception Design Ltd.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SECURITY
VENTILATION
SHAPE
ACCESS
SATISFAC
CIRCU
ORIENTATION
FURNITURE
RADIANT TEMPERATURE
AESTHETICS

LIGHTING

INTRODUCTION

These recommendations apply to the use of general lighting systems to the lighting of spaces in which the VDTs are more or less randomly located and in which they are in continual use. If the VDTs are used only very occasionally - for example, in referring to a stock list - then the recommendations still apply although a lighting system of the type traditionally used for office lighting may also prove acceptable.

With some exceptions (which are obvious from the text) the recommendations apply to VDTs with multicolour screens and with monocolour screens (with positive and negative contrast).

Not enough is known of the operations of a VDT with a horizontal screen to permit firm recommendations to be made on the methods of lighting the spaces accommodating those VDTs. However, it is considered very probable that the positive contrast screen and the multicolour screen will need extensive shielding to eliminate "washout" caused by the lighting system. Further, it is considered possible that such shielding will be required for the negative contrast screen.

DISPLAYS

1.0 The minimum character size shall be 3.0 mm (assuming a viewing distance of 50 cm) or 18 minutes of arc.

(PRODUCT SPECIFICATION)

2.0 The character size shall not be obtained at the expense of image quality.

(PRODUCT SPECIFICATION)

3.0 The characters shall be sharp, well-defined, and unambiguous. They shall not lose their identity as their brightness is varied. Check, for example, that I can be distinguished from L as the brightness is increased.

(VISUAL INSPECTION)

4.0 The characters shall be upright and not slanting.

(VISUAL INSPECTION)

5.0 A display with both upper case and lower case characters is preferred.

(PRODUCT SPECIFICATION)

6.0 In a display with lower case characters the descenders shall project below the base line of the matrix.

(PRODUCT SPECIFICATION)

7.0 If the characters are generated by individual dots, a 5 x 7 matrix is acceptable but a 7 x 9 or greater matrix is preferred.

(PRODUCT SPECIFICATION)

8.0 The character width shall be 70-80% of the upper case character height.

(PRODUCT SPECIFICATION)

9.0 The stroke width shall be 12-17% of the character height.

(PRODUCT SPECIFICATION)

10.0 The space between characters shall be 20-50% of the character height.

(PRODUCT SPECIFICATION)

11.0 The row spacing shall be 100-150% of the character height.

(PRODUCT SPECIFICATION)

12.0 It is preferred that the display be provided with a cursor. The cursor shall be clearly distinguishable from the other symbols in the display and it shall be possible to suppress the blink action of the cursor.

(PRODUCT SPECIFICATION)

13.0 The display shall be big enough to present the information required by the operator.

(VISUAL INSPECTION/PRODUCT SPECIFICATION)

14.0 Positive or negative contrast screens are both acceptable. (There is no clear evidence from current research that one form of contrast is superior to the other.)

(PRODUCT SPECIFICATION)

15.0 For a positive contrast screen the luminance contrast between the characters and the background shall be within the range 5:1 to 10:1 and, for a negative contrast screen the luminance contrast between the background and the characters shall be within the range 5:1 and 10:1. The luminance of the characters and the background shall be variable.

(LUMINANCE MEASUREMENT/PRODUCT SPECIFICATION)

16.0 Consideration shall given to the use of colour or luminance coding in the display. This shall take into account the number of colours or the number of luminance levels to be distinguished.

(PRODUCT LITERATURE EVALUATION)

17.0 The minimum refresh rate for a positive contrast display shall be 50 Hz at 25 frames per second for an interlaced display. The minimum refresh rate for a negative contrast display shall be greater than 50 Hz at 25 frames per second for the interlaced display.

(PRODUCT SPECIFICATION)

18.0 Primary work surfaces shall not be glossy while keyboards shall have a matt finish of medium to high reflectance and shall also have black characters.

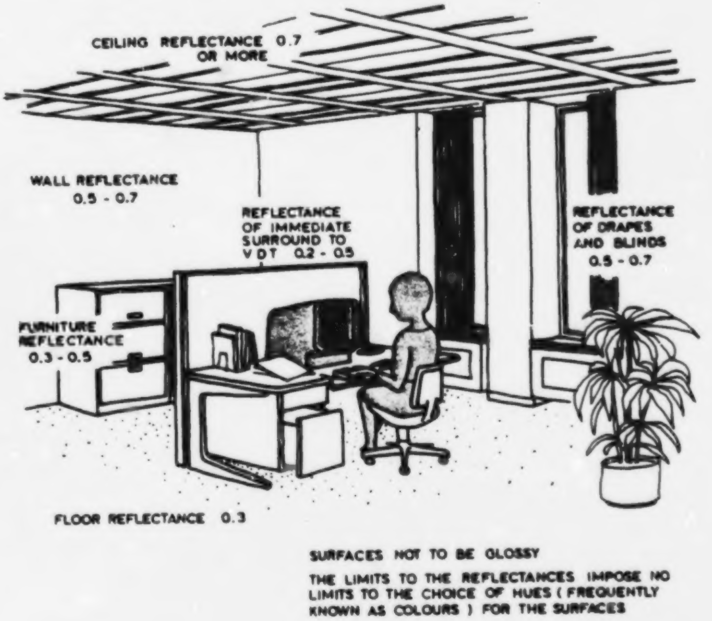
(PRODUCT SPECIFICATION)

REFLECTANCES AND FINISHES OF PRINCIPAL SUREACES IN SPACES CONTAINING VDTs

19.0 Reflections and finishes of primary work surfaces in space containing VDTs shall have the specified reflectances.

CRITERION:	Immediate surround of VDT:	0.2 - 0.5
	Ceiling:	0.7 or more
	Walls and Window shades and blinds:	0.5 - 0.7
	Floor:	0.3
	Furniture:	0.3 - 0.5

(REFLECTANCE MEASUREMENT)


CEILING REFLECTANCE 0.7 OR MORE
WALL REFLECTANCE 0.5 - 0.7
REFLECTANCE OF IMMEDIATE SURROUND TO VDT 0.2 - 0.5
REFLECTANCE OF DRAPES AND BLINDS 0.5 - 0.7
FURNITURE REFLECTANCE 0.3 - 0.5
FLOOR REFLECTANCE 0.3
SURFACES NOT TO BE GLOSSY
THE LIMITS TO THE REFLECTANCES IMPOSE NO LIMITS TO THE CHOICE OF HUES (FREQUENTLY KNOWN AS COLOURS) FOR THE SURFACES

19.0 FINISHES AND REFLECTANCES OF PRINCIPAL SURFACES IN SPACE CONTAINING VDT'S

ILLUMINANCE (LIGHT LEVEL)

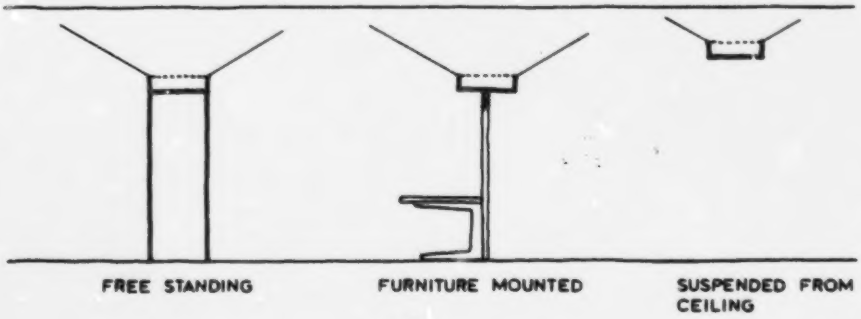
20.0 An illuminance in the range 300 - 500 lux (30-50 footcandles) shall be provided on horizontal work surfaces approximately 750 mm above the floor. (It may be necessary to increase this illuminance locally if, for example, the work involves the use of poor quality copy.)

(ILLUMINANCE MEASUREMENT)

LIGHTING SYSTEMS

21.0 The illumination shall be provided by either:
a) an indirect lighting system producing a ceiling of substantially uniform luminance or,
b) a direct lighting system using low luminance luminaires or,
c) a combination of the above indirect and direct lighting systems.

(PRODUCT SPECIFICATION)



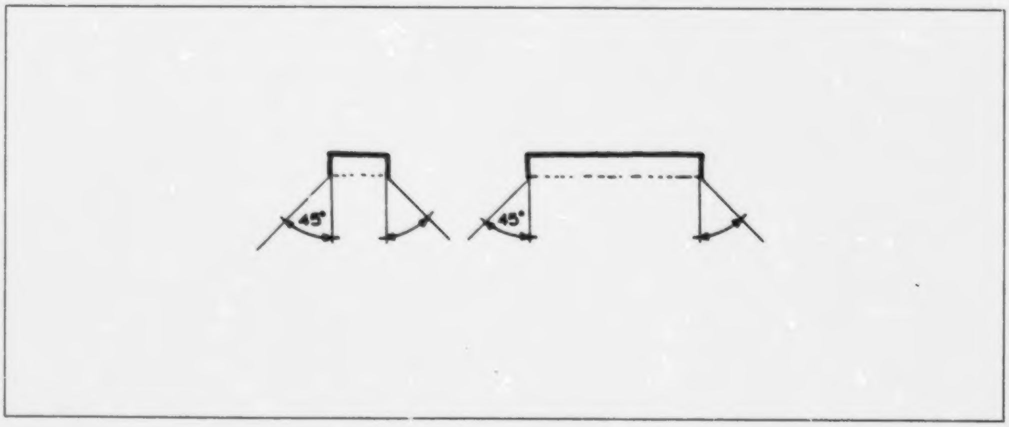
21.0 TYPICAL TYPES OF LUMINAIRES

22.0 The indirect lighting system shall produce a maximum average ceiling luminance of 500 cd.-m^{-2} (150 fL) with a maximum "hot spot" ceiling luminance of 1500 cd.m^{-2} (450 fL). There shall be no abrupt changes in the ceiling luminance.

(LUMINANCE MEASUREMENT)

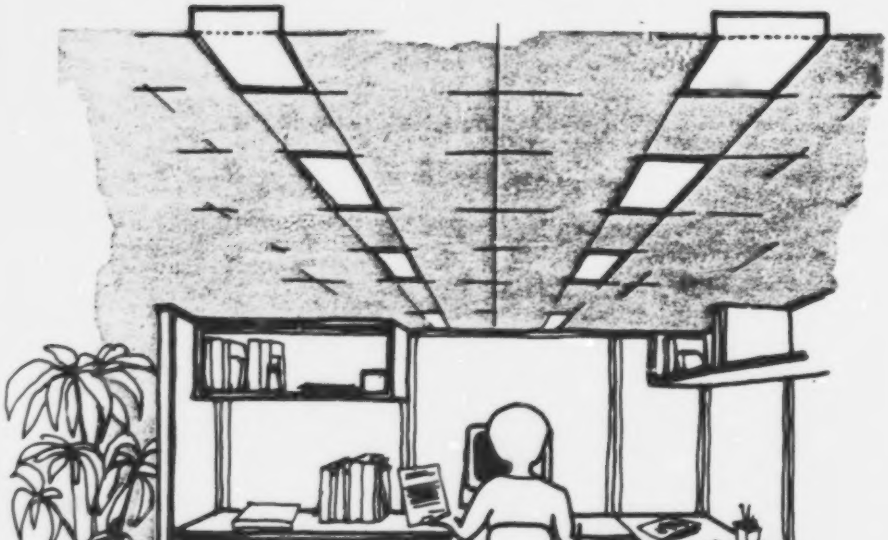
23.0 The luminaires used in the direct lighting system shall have a maximum luminance of 200 cd.m^{-2} (60 fL) at angles above 45° to the nadir. Also, the luminaires shall not have a bright perimeter.

(LUMINANCE MEASUREMENT)



24.0 The luminaires used in the direct lighting system shall preferably be located at the sides of and not directly above the VDTs.

(VISUAL INSPECTION)



25.0 Enough light shall reach the walls to ensure that they are comfortably bright. With the direct lighting system, this may require some luminaires to be located near the walls and/or the provision of a supplementary wall-washing lighting system.

(VISUAL INSPECTION)

26.0 If necessary, local lighting shall be provided at each work station.

(ILLUMINANCE MEASUREMENT)

LAMPS

27.0 Where colour rendering is not important, lamps with a Colour Temperature or a Correlated Colour Temperature of about 3000K shall have a minimum General Colour Rendering Index (R_a) of about 55. Lamps with a Colour Temperature or a Correlated Colour Temperature of about 4500 K shall have a minimum General Colour Rendering Index (R_a) of about 65.

(PRODUCT SPECIFICATION)

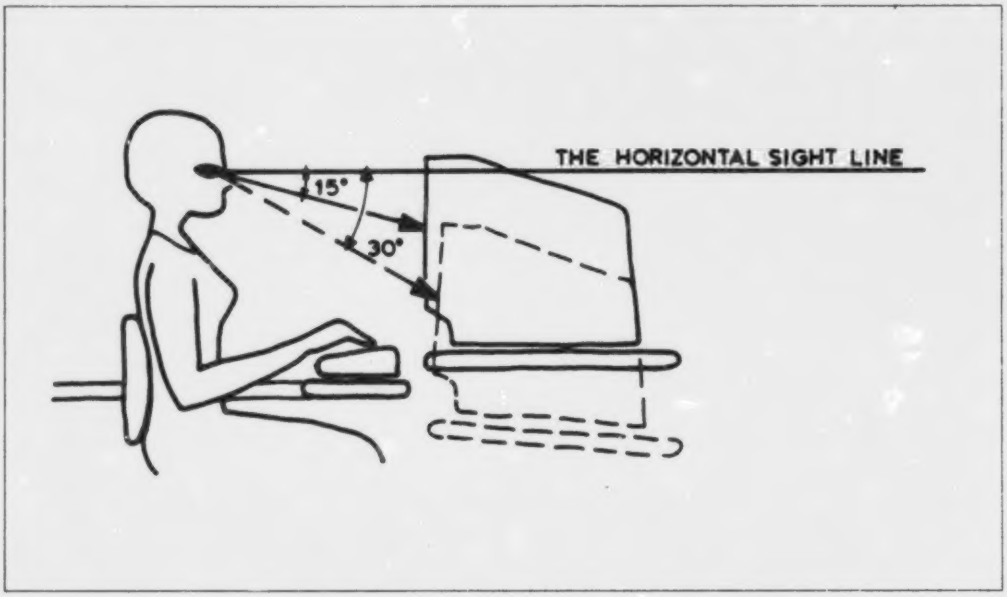
VDT OPERATION

28.0 The screen shall be capable of being tilted and rotated and the movement shall be provided in the keyboard and VDT equipment.

(PRODUCT SPECIFICATION)

29.0 The center of the screen shall be lower than the eyes of the VDT operator. The slope of the line of sight to the center of the screen shall be between 15° and 30° to the horizontal.

(PRODUCT MEASUREMENT)



30.0 If necessary, the VDT shall have a visor to help eliminate bright reflections in the screen.

(VISUAL INSPECTION)

31.0 If necessary, the VDT shall have a filter over the screen to help eliminate bright reflections in that screen.

(VISUAL INSPECTION)

WALL BRIGHTNESS

32.0 Enough light shall reach the walls to ensure that they are comfortably bright. (This may require some luminaires to be located near the walls and/or the provision of a supplementary wall-washing lighting system).

(VISUAL INSPECTION)

33.0 General Colour Rendering Index (R_a) of lamps used in a space where colour rendering is not of special importance, shall be:

- a minimum of 55 for lamps of a Colour Temperature or Correlated Colour Temperature of about 3000 K.
- a minimum of 65 for lamps of a Colour Temperature or Correlated Colour Temperature of about 4500 K.

(PRODUCT SPECIFICATION)

MAINTENANCE

34.0 The VDT screen and filter (if one is used) shall be kept clean and free from finger marks.

(VISUAL INSPECTION)

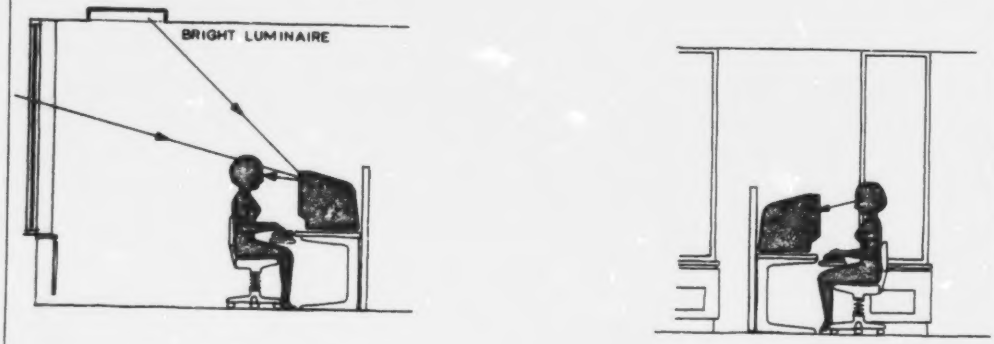
35.0 The luminaires shall be kept clean. Particular care shall be taken to remove all traces of detergent from low luminance luminaires.

(VISUAL INSPECTION)

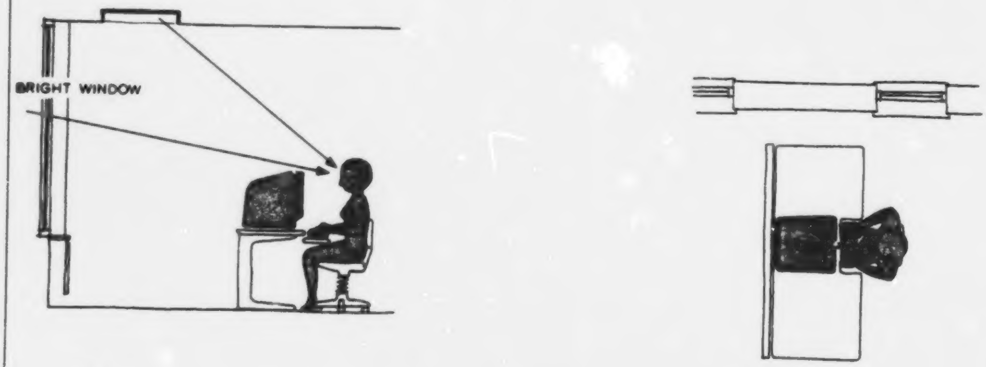
LOCATIONS OF VDT OPERATORS

36.0 The operators shall sit so that their lines of sight are substantially parallel to the windows.

(PLAN EVALUATION/VISUAL INSPECTION)


BRIGHT LUMINAIRE

POOR LOCATION OF VDT OPERATOR


BRIGHT WINDOW

**GOOD LOCATION OF VDT OPERATOR
(SIGHT LINE PARALLEL TO WINDOW)**

37.0 The operators shall not sit with their back to:

a bright luminaire or a bright window (both of which may produce bright reflections in the VDT screen)

a bright window screened by a partly opened venetian blind (which may produce sharply defined light and dark stripes in the VDT screen).

a window which is much darker than the surrounding walls (since it can produce sharply defined light and dark areas in the VDT screen. Drapes or blinds of appropriate reflectance shall be drawn over the dark window.)

(PLAN EVALUATION/VISUAL INSPECTION)

38.0 The operators shall not face:

a bright luminaire or a bright window.

a bright window screened by a partly open venetian blind.

a window which is much darker than the surrounding walls. (drapes or blinds of appropriate reflectance shall be drawn over the dark window)

(PLAN EVALUATION/VISUAL INSPECTION)

BASES FOR PERFORMANCE REQUIREMENTS

1. General

Many people now use the video display terminal (VDT) for much of the working day and their numbers are growing rapidly. The Intel Corporation[1] has estimated that by the early 1990's every office worker will have a VDT. The use of VDTs has consequently been of great interest to management and union alike and has generated world-wide comment.

Many VDT operators have experienced symptoms of visual discomfort or visual fatigue - frequently referred to as "eye- strain". There is evidence which strongly supports the contention that working at a VDT gives rise to eye-strain more frequently than do other kinds of work.[2] However, a detailed study indicates that VDTs alone are not the cause of the problem: it is due also to other aspects of the job situation including workstation, lighting and job design.[3]

Many reports have discussed the influence of the visual environment on the comfort and well-being of VDT operators: two of these reports were published in Canada in 1982.

The first report, "In the Chips",[4] published by Labour Canada, recognizes that some of the visual problems of VDT operators might be caused by the "legibility of the display screen, glare from the screen ... the general standard and layout of *illumination*". The second report,[5] - based on a study of nearly 400 operators for the Quebec Association of Ophthalmologists - states that "manufacturers of VDTs should be required to build them with anti-glare screens ... and employers should ... be responsible for improving existing lighting conditions".

In addition to the visual problems mentioned above there are other personal factors which could affect the well-being of a VDT operator. "In the chips" states:

> Some of the other physical complaints of VDT operators, such as head, shoulder, and neck problems, would also relate, in part, to the need to look frequently in different directions. Complaints touching on back and wrist seen to be more closely related to postural immobility throughout many hours on the equipment. The (Labour Canada) Task Force believes that the alleviation of eye problems will also, in part, help alleviate some of these other physical symptoms.

> We also recognize that some of these physical problems might be caused by ergonomic considerations related to either the equipment itself or the work site. Some of these ergonomic factors, for example, might be legibility of the display screen, glare from the screen, nonadjustable office furniture (especially seating), the general standard and lay-out of illumination, and such.

None of these sources of discomfort is unique to VDT users. Many workers experience 'eyestrain' when trying to read low contrast images or when experiencing glare from poorly shielded luminaires.

Badly designed work places can lead to awkward and cramped postures and these can create muscular fatigue and headaches.

The problem has been made more difficult by the fact that a substantial proportion of the working population typically has uncorrected or inadequately corrected visual defects. Estimates of the exact proportion vary but it is likely to be between 20% and 30%.[6] The result has been that a number of VDT users who have experienced various symptoms of discomfort in their eyes have been told, when they consulted their eye doctor, that they needed glasses. Inevitably, they have connected the need for glasses with VDT use. This connection has appeared particularly obvious when clerical workers have been transferred to VDT operation since optimum vision may not be required in a variety of jobs, including much clerical work.

The recommendations contained in this report are intended to ensure a lighting system which:

- will provide a visual environment in which a VDT operator can be expected to see well and comfortably.
- can be used in a general office containing many workstations with VDTs as well as in a private office.

2. Reflectances and finishes of principal surfaces in space containing VDTs

Whichever recommended lighting system is used, the surface reflectances of the walls, ceiling and floor must be high if the impression of gloom is to be avoided. The recommended reflectances are:[7]

Area immediately surrounding VDT screen:	0.2 - 0.5
Ceiling:	0.7 or more
Walls:	0.5 - 0.7
Blinds:	0.5 - 0.7
Floor:	0.3

Although the limits to the reflectances are specified there are, of course no limits - apart form those of taste to the choice of hue (colour).

The use of high reflectance surfaces has the advantage of increasing the diffuse illumination in an interior. This will tend to diminish the prominence of any high luminances that do exist. However, the surfaces must not be glossy.

The method of determining the approximate reflectance of the surface either by measurement or from Munsell system of colour notation is given in the Lighting Requirements.

It is recommended that the keyboard have a matt finish of medium to high reflectance with black characters on the keys.

3. Displays

3.1 A positive contrast screen is one in which bright characters appear on a dark background.

A negative contrast screen is one in which dark characters appear on a light background.

The above use of the terms 'positive contrast' and 'negative contrast' follows North American convention. European convention refers to bright characters on a dark background as negative presentation and to dark characters on the light background as positive presentation.[8]

3.2 There is no clear evidence that one form of contrast is superior to the other.[9]

The average luminance (measured brightness) of a negative contrast screen is usually not severely different from that of the source documents. Consequently, the eyes of the operator do not have to adapt first to the screen luminance and then to the different source luminance.

On the other hand the average luminance of a positive contrast screen is usually less than that of the copy. It has been assumed that the operator's eyes adapt first to the dark screen and then to the brighter documents. Visual losses causing 'eyestrain' could arise from this process of adaptation.

However, it has been suggested[10] that the operator does not adapt to the dark screen but, instead, to the bright characters on the screen. The luminance of the characters is not usually severely different from that of the documents so that the minimum visual losses should occur as the operator turns from screen to documents.

It has been concluded that "the situation needs to be examined further".[11]

3.3 There is no clear evidence that any one colour is best for a monocolour display.[12] The choice of colour can be based on personal preference.[13]

Most VDTs use either a white or a green phosphor, although some displays use a white phosphor in combination with a colour filter to produce yellow or orange displays. The latter colours are popular in Scandinavia. For the most part, the colour of the display, all other characteristics being equal, will have no influence on physiological measures, such as contrast, sensitivity and acuity.

There is a concern that, with multicoloured displays, chromatic aberration of the eye will cause the red and blue ends of the spectrum to be less accurately focused than green (or achromatic) display.

There are no known performance differences associated with differences in the colour of the display used.[12]

3.4 The characters must not lose their identity as their brightness is varied. For example, I must remain clearly distinguishable from L as its brightness is increased.

3.5 The brightness of the characters should be under the control of the operator.

With a positive contrast screen the ratio of the character luminance to the background luminance should be within the range of 5:1 to 10:1. If the ratio is greater than 10:1 the characters appear too bright: complaints may occur.

With a negative contrast screen the ratio of the background luminance to the character luminance should be within the range of 5:1 to 10:1.

It is not possible to measure character luminance with a simple photometer of the type used to measure illuminances provided by a lighting system.

3.6 The bright characters are made up of a series of light pulses. If conditions are correct, the characters will appear to be steady: if not, they may appear to flicker.

Various factors influence a person's ability to perceive flicker - for example, frequency, size and brightness of characters, and waveform. Frequency - known as the refresh rate - is the most obvious factor.

Most displays have a minimum refresh rate of 25 - 30 Hz (cycles per second). This assumes an interlaced display in which one half of the character is refreshed during one cycle and the other half during the next cycle and so on, giving an effective refresh rate of about 50 - 60 Hz. The phrase "about 50 - 60 Hz" is used since the effect is not exactly the same as that from a refresh rate of 50 - 60 Hz applied to a display which is not interlaced.

It has been reported that flicker has the ability to induce epileptic seizures. Studies have demonstrated, however, that the flicker frequency must be low - typically in the 8 - 14 Hz region - in order to induce these seizures in sensitive people. Since, as stated above, most VDTs have a refresh rate well above this range, "there appears to be no significant (seizure) problem .... induced by most existing displays."[15]

3.7 The display should be big enough to present the information required by the operator. There are no standard requirements for screen size but the characters which appear on the screen must be a certain minimum size. Thus the more information required on the screen, the bigger the screen.

3.8 If the characters are too large reading time is reduced because of the increase in eye movement. On the other hand, large characters are desirable in a search-type display. A minimum character size of 3.0 mm or 18 min. of arc appears to be a meaningful standard at the present time.[16,17]

The above specification takes into account the large variability among operators. It assumes a minimum viewing distance of 50 cm although larger distances are feasible for some particular tasks and work place geometries. If a longer viewing distance is anticipated then the characters should meet the size requirement of 18 min. of arc.

The character size should not be obtained at the expense of image quality. For example, character size may be increased by increasing the pitch of the raster lines. This can be detrimental because the visibility of the raster lines reduces performance.

4. Illuminance (Light Level)

Where the operator's task involves both VDT and paperwork, a compromise illuminance (light level) is required which is bright enough for the paperwork without reducing screen contrast. A general illuminance of between 300 and 500 lux (30 to 50 footcandles) should prove an acceptable compromise between conflicting demands of the task.[18] Additional local lighting on the copy may be essential if the copy is of poor quality.

The recommended illuminance of 300 - 500 lux (30 to 50 footcandles) is about one-half that provided in many offices for conventional office. This reduction is illuminance should result in a reduction in energy consumption.

5. Lighting System

5.1 Two general lighting systems at present available are suitable for VDT lighting.

(a) indirect lighting (in which the light from the luminaires is directed to the ceiling which acts as a diffuse reflector to reflect the light down to the work).

(b) Direct lighting using luminaires (probably mounted in or on the ceiling) which are of low luminance.

With (a), the ceiling luminance should be substantially uniform without strongly defined bright or dark edges to the patches of light. Reflections seen in the screen will thus be uniformly bright. They will not be as disturbing as the bright reflection of one or more bright luminaires seen against a dark ceiling.

The ceiling should have a maximum average luminance of 500 cd.m^{-2} (150 footlamberts) with a maximum "hot-spot" luminance of 1500 cd.m^{-2} (450 footlamberts). It should be noted that research does not appear to have established limits to the ceiling luminance. The above values are derived from practice which has resulted in an appropriate visual environment.

With (b), the low luminance luminaire should have a luminance of less than about 200 cd.m^{-2} (60 footlamberts) at angles about 45° to the nadir. Fluorescent luminaires fitted with proprietary "Parawedge" or "Paralouver" louvres may comply with this limiting luminance although the luminaires are likely to be of low efficiency.

5.2 Many VDTs have keys which are glossy, light in colour, and slightly concave. The concavity appears to concentrate the image of an overhead luminaire into a bright spot. This makes it difficult for a "hunt and peck" operator to read the character on a key. Keys with bright spots are a frequent cause of complaints of these operators although touch typists do not usually raise this complaint.

With low luminance luminaires the bright spots are usually eliminated if the luminaires are located to the sides of the VDTs rather than directly above the keyboard.

5.3 The low luminance luminaires direct their light downwards rather than to the sides or upwards. Consequently, unless care is taken in the design of the lighting system, little light from these luminaires may reach the walls; even when they are of the appropriate reflectance the walls may appear dark. It may be necessary to locate some of these luminaires close to the walls so that light reaches the walls or else to provide a supplementary system of wall-washing luminaires.

5.4 Additional local lighting on the copy may be essential.

5.5 The lighting is a factor of the office environment which comes in for criticism. This criticism can arise in part from a poorly designed lighting system; in part from the fact that the lighting system is very visible in an office; and in part from the fact that with most lighting systems the worker cannot control his own lighting.

The latter point has been echoed in the literature - possibly most appropriately by Brundrett, the distinguished lighting researcher with the (British) Electricity Council Research Centre. He has stated that "people differ in their needs. Fixed environmental conditions will only satisfy a proportion of the population .... a new engineering approach is required to provide the flexible environment".[19]

General lighting systems, such as those discussed here, are systems traditionally used for office lighting: they provide substantially even illuminance all over an office from, for example, a regular array of fluorescent luminaires in the ceiling.

Those who work in lighting know from experience that even a carefully designed general lighting system for general office work - *not* for an electronic office - will be criticized by some of the workers. But the electronic office with, for example, its word processors, imposes seeing conditions which are more severe than, and are not found in, general office work.

It is the experience of the lighting consultant that the proportion of complaints about lighting in an electronic office is much higher than that for general office work. This experience is substantiated by the observation that working at a VDT gives rise to eyestrain more frequently than does other kinds of work.

If the lighting consultant were to design afresh a lighting system for an electronic office in which VDTs are in regular use for some hours at a time, he would consider a flexible system giving the worker some control over the lighting. Such an approach does not yet appear to have been attempted: until it is, complaints by workers in electronic offices will continue to be made about general lighting systems.

The brightness of a VDT (or similar device) is to be used only infrequently and for a short period - for an occasional check of stock, for example - There is probably no need for this approach.

6. Location of VDT Operator

A problem is caused by bright windows or luminaires in the field of view of the operator. When the operator is not looking at the VDT screen, he looks up and catches sight of the bright window. His eyes adapt to the bright visual environment which they produce. When he looks back at the screen his eyes need time to adapt to the lower light level. This can take some seconds. However, studies have shown that many VDT operators look quite frequently at the screen for short periods of time. This does not allow sufficient time for the eyes to adapt. Operators may therefore spend some time using their eyes sub-optimally adjusted to the images on the screen. This could be a factor in increasing fatigue.[20] The lighting system should thus not have bright luminaires or windows in the field of view.

The problem is not solved by locating the operator with his back to the luminaires or windows. Then the luminaires will probably create bright patches on the screen while light from the window will probably "wash-out" the screen. Windows with partly open venetian blinds can be particularly troublesome, especially those behind the operator, as they can create alternate dark and bright bands on the screen.

An offending luminaire or window can be identified by locating its reflection in a mirror placed flat against the surface of the screen.

6.1 Operator with vertical or near vertical screen

The operator should not face or sit with back to:

- A bright luminaire or window or a bright window screened by a partly open venetian blind.
- A window which is much darker than its surrounding walls. This could be the situation at night. Blinds or drapes of reflectance specified in Article 2 should be drawn over the dark window.

6.2 Operator with horizontal screen

The operator should not face a bright luminaire or window or a bright window screened by a partly open venetian blind.

7. VDT Operation

7.1 Use of tilting and rotating screen and screen visor

A screen which can be tilted and rotated will help to reduce screen reflections while a visor around the screen can help to minimize screen "wash-out".

7.2 Use of filters

The luminance of bright reflections in the screen with respect to the screen characters can be reduced by a filter placed in front of the screen. However, a filter will diffuse these characters to varying degrees, thus making them less legible.

Many types of filter are available, ranging in price from about $5.00 to more than $100.00 and having an equal range of effectiveness. The effectiveness of a particular filter depends on many variables and combinations of variables, so it is possible only to discuss the issue of effectiveness in a general sort of way. In general, filters are more effective in reducing diffuse reflection than in reducing specular reflection.[21] This is unfortunate because the latter reflections cause the greater loss of contrast and probably contribute more to the problems encountered in viewing VDTs.

A circular polarizer filter with anti-reflection coating or a filter with multiple layers of thin-film optical coatings can be used to reduce both specular and diffuse reflections. They are the most expensive filters available and probably two of the most effective. A problem with the thin film antireflection coatings is that dirt and finger-prints show up strongly on the surface of the filter: hence the filter may have to be cleaned often.

A neutral density filter is the simplest of the contrast enhancement filters. It typically consists of a neutrally tinted plastic which transmits some 15-25% of the light that falls on it. The light from the luminaires or windows is attenuated twice as it passes through the filter. However, the light from the characters passes through the filter only once, consequently the display contrast is improved.

Specular reflections may not be reduced by this type of filter unless the surface of the filter is treated with an anti-reflection coating or has a matt finish coating that blurs the specular reflections.

A filter that is apparently not commonly available but that would appear to be both effective and inexpensive is a neutral density filter formed into a spherical concave shape.. A spherical screen with this filter is tilted so that only reflections of the operator's chest and abdominal areas are seen. If these areas are kept somewhat dark, for example by an operator wearing dark clothing, specular reflections should not be a problem. Diffuse reflections would be reduced as they are with any neutral density filter.

The principle of the colour filter is essentially the same as that of the neutral density filter with the exception that the transmittance properties of the colour filter are tuned to the colour of the characters. The filter reduces the diffuse reflections on the screen but, as is the case of the neutral density filter, the control of specular reflections depends on the surface treatment of the filter.

Directional filters use geometric or optical means to prevent ambient light from reaching the VDT or to prevent reflections from reaching the operator. One type of directional filter is a thin sheet of transparent material with tiny, opaque, imbedded slats that are perpendicular to the sheet. The slats act as a miniature venetian blind, allowing light to travel only in certain directions. Contrast loss due to diffuse reflections is reduced when the slats are oriented toward the operator. Specular reflections, however, would have to be reduced by the surface treatment of the filter, as discussed above.

7.3 Use of acoustic screens

Acoustic screens are a means of obscuring bright windows and luminaires from the view of the VDT operator. If, however, the recommendations contained in this report are followed, the use of acoustic screens for this purpose should be unnecessary.

It should be noted that if a small "cell" is formed of acoustic screens, then those screens may prevent an adequate air exchange in the "cell" and also considerably reduce the light reaching the work surface.

8. Maintenance

8.1 The VDT screen (and the filter, if one is used) should be kept clean and free from fingerprints in order to permit the characters to be seen clearly and to reduce unwanted reflections. Cakir has reported that a sum of £25,000 was spent to change a lighting environment in order to make the VDT characters legible when all that was necessary was to clean the surface of the screen.[22]

8.2 The luminaires must be kept clean if their efficiency is to be maintained. Moreover, if low luminance louvres (such as the "Parawedge" and "Paralouver") are not kept free from dust (including tobacco smoke) the dust will pick up light from the lamps and destroy the low luminance property of the luminaire.

No trace of detergent must be left on the "Parawedge" and "Paralouver" louvres after washing as it may fluoresce a pale blue under the action of the ultraviolet radiation from a fluorescent lamp.

9. The Sight of VDT Operators

The (British) Visual Display Unit Eye Test Advisory Group[23] has developed a standardized package of eye-tests for workers who operate VDTs. A copy of these tests forms Appendix A to this report. The Group does not recommend that all VDT operators should undergo such tests, but rather that operators should have their eyes tested more frequently than they usually do.

The viewing distance for VDTs is frequently (if not usually) different from the distances for which glasses are usually prescribed. For this reason it seems desirable that, when prescribing occupational glasses, the eye doctor should make himself aware of how an operator works at a VDT. For viewing VDTs and associated visual tasks, as for most forms of similar commercial work, it is necessary to have normal visual acuity, a correction for any significant refractive errors, and a near addition for the middle-aged operator.[24] The Advisory Group does recommend that where the use of VDTs is particularly intensive or prolonged, or where there is concern over fatigue caused by inadequate attention to ergonomics, then a long term check should be kept using the test mentioned above.

10. Legislation and Guidelines

A number of countries have issued guidelines and, in some cases, enacted legislation, on the design and use of VDT equipment and work places. Comments are made below on a number of these publications. Some of the comments must be taken as tentative pending the examination of firmer source data.

10.1 Canada

"In the chips"[4] published by Labour Canada (1982) recommends that ergonomic standards be developed for office automation equipment and work places to cover such factors as the physical environment and the design of office equipment and furniture. In the interim period, until such standards are adopted by the appropriate legislative bodies, "In the chips" suggests that employers accept the following guidelines concerning VDTs:

- that pregnant women have the right to be reassigned to other positions without loss of pay, seniority and benefits;
- that the maximum time limit for VDT operators not exceed five hours per day;
- that rest breaks for VDT operators be provided hourly;
- that initial eye tests, followed by annual retesting be conducted for VDT operators at employer's expense;
- that corrective lenses specially adapted to the visual demands of VDT work be provided to the employee, where necessary.

In Ontario, a Private Member's Bill (#149) "An Act to Safeguard Terminal Operators"[25] was introduced into the Legislature in 1981: it has since died. The Bill briefly outlined standards for VDTs and the associated furniture and provided that "every employer of a terminal operator shall allow the operator a fifteen minute rest period with pay for every two hours that the operator works and shall not cause the operator to work any continuous period exceeding two hours."

Another Private Members' Bill (#83) "An Act for the Protection of Video Display Terminal Operators" received its final reading on June 21, 1983. (See Appendix B)

The Ontario Public Service Employees Union in its publication "The Hazards of VDTs" (1981)[27] states that "The Ontario Occupational Health and Safety Act has no regulations or even guidelines that apply to VDTs".

10.2 Australia

It has been reported[28] that "VDUs and Ill-Health: The Evidence" published by the Australian Postal and Telecommunications Union states that there is "a sufficiently large body of evidence to cast grave doubts on the claim that (VDTs) are completely safe". The Union's concluding policy statement calls for a three-day week for full-time operators until more is known about the VDTs.

10.3 France

Robert De Matteo of the Ontario Public Service Employees Union stated (1983-11-07) in discussion with the author of this report that France "has classified VDT operation as a hazardous occupation".

10.4 Germany

The German standards institute (the DIN) has published a Standard 66234 (1982)[29] dealing with the keyboard characteristics for VDTs: the display spacing; the symbol characteristics; the screen characteristics; the illumination and glare characteristics; the viewing geometry and the workstation dimensions. A green through orange colour is specified for the screen characters. The illuminance specified is 300 - 500 lux for positive contrast screens and more than 500 lux for negative contrast screens.

The acceptability of VDT based equipment in Germany is influenced by how well it conforms to the DIN standard.

The German Centre for Accident Prevention and Industrial Health (the ZUA) has published (1980) the German Safety Standards.[28] These cover most of the features included in the DIN publication mentioned above but they recommend no illumination requirements while the preferred colour for the screen characters is specified as "not red or blue".

Rinalducci et al[30] state that the German Safety Standards become "legally binding specifications" when written into contracts.

When working at the Technical University of Berlin (1978) Cakir et al[29] recommended an illuminance of 500 lux and the use of yellow-green screen characters. Subsequently (1980), with Hart and Stewart, Cakir[22] recommended 300 - 500 lux and left the colour of the display to personal preference.

10.5 Norway

According to the "New Scientist" (1981-05-07)[31] the Norwegian Labor Directorate introduced draft rules that would prevent operators from working at VDTs for more than two hours without a break. The regulations would also require, among other things, that operators spend no more than half their time doing straight typing.

10.6 Sweden

The Swedish National Board of Occupational Safety and Health published (1979) a National Directive entitled "Reading of Display Screens" which contains recommendations similar to those of the German DIN standard. Stewart[32] has pointed out that, even prior to this National Directive, Swedish employees were entitled to insist on ergonomically designed work places under the Work Environment Act (1978-07-01).

10.7 United Kingdom

The Health and Safety Executive has issued a guidance note on the use of VDTs. Although this document does not carry the force of law it could make it difficult to introduce unsuitable equipment in unionized industries.

10.8 United States of America

The State of Maine has passed a bill specifying the occupational safety and health requirements for VDT operators.[33] (See Appendix C)

A bill on the same subject has been passed in the State of Illinois.[34]

It has been reported that the Massachusetts legislature was to consider a VDT safety bill (House Bill 2910) during its 1982 session.[35] This bill apparently includes a number of ergonomic requirements for VDT work stations and calls for periodic rest breaks and annual eye examinations for operators.

NIOSH[36] recommends that:

"1. A 15-minute work-rest break should be taken after two hours of continuous VDT work for operators under moderate visual demands and/or moderate work load.

2. A 15-minute work-rest break should be taken after one hour of continuous VDT work for operators under high visual demands, high workload and/or those engaged in repetitive work tasks."

NIOSH goes on "While there is no research evidence that this work-rest schedule will be sufficient to deal with all of the reported problems, it is felt that this schedule should be tried before more disruptive schedules (such as job rotation) are implemented.

11. Glossary

Adaptation: The process by which the eye adjusts to the luminances or the colour stimuli presented to it. (If one enters a movie theatre from bright daylight the eye will take some time to adapt to the dark interior.)

Illuminance (sometimes also referred to as illumination; level of illumination; lighting level): The concentration of luminous flux on a surface.

The unit used in Canada has been the footcandle (fc) which is equivalent to the illuminance of 1 lumen uniformly distributed over a surface area of one square foot.

The SI (or metric) unit is the lux (SI symbol: lx). One lux is the illuminance of 1 lumen uniformly distributed over a surface area of one square metre (1 m^2).

This 1 fc = 10.76 lx or 1.076 dalx

Lumen (lm): The unit of luminous flux - the stuff we call light. For example, a new 100 W lamp may emit 1700 lm.

Luminance: The concentration of luminous flux emitted from a luminous or reflecting surface.

The unit used in Canada has been the footlambert (fL) which is equivalent to 1 lumen transmitted through or reflected by one square foot of surface.

The SI unit is the nit (nt) which is equal to 1 candela per square metre (cd/m^2). (The candela [cd] is the SI unit of luminous intensity.)

Thus 1 nt = 0.3 fL

In everyday speech the term "brightness" is used loosely instead of "luminance". Thus, one might say that "the brightness of that wall is 10 cd/m^2" when, to be correct, the term "luminance" should have been used. Luminance is a measured quantity; brightness is not.

Reflectance: The ratio of the reflected flux to the incident flux - that is, the percentage of light falling on a surface that is reflected.

Colour temperature: Current passing through the tungsten filament of an incandescent lamp raises its temperature and causes it to give off light. For a given filament, the greater the current, the hotter the filament and the whiter the light. It is possible to specify the whiteness of the filament in terms of its temperature - called the Colour Temperature. The unit is the Kelvin (K).

Correlated colour temperature: Used to specify the whiteness of fluorescent and other discharge lamps. The unit is the Kelvin (K).

General Colour Rendering Index (R_a): The effect of light on coloured objects is known as colour rendering. The General Colour Rendering Index (R_a) gives an indication of how closely a given light source matches the colour rendering ability of a reference source.

Indirect lighting system: Lighting by luminaires distributing 90 to 100 per cent of the emitted light upwards. The ceiling usually acts as a reflector to re-direct the light down to the work surfaces.

Direct lighting system: Lighting by luminaires distributing 90 to 100 per cent of the emitted light in a downward direction.

Nadir: The downward vertical (straight down).

Hertz (Hz): Frequency measured in cycles per second. Thus instead of referring to a frequency of 60 cps one refers to 60 Hz.

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ELECTRONIC OFFICE DESIGN GUIDE

HUMIDITY
FUNCTION
SECURITY
VENTILATION
AIR QUALITY
SUBJECTIVE
SOCIAL
ACCESS
ERGONOMICS
CLOTHING
ORIENTATION
FURNITURE
RADIANT TEMPERATURE

ACOUSTICS

INTRODUCTION

The acoustical aspects of an office environment play a vital role in determining the satisfaction of the occupants. Studies indicate that office workers consider the most important requirement in their workplace to be the ability to concentrate without distraction. Speech privacy is also sometimes cited as an essential requirement particularly by managerial and professional staff. These requirements need special design considerations for all types of offices but especially for the open plan layout. The proximity between workers and an absence of walls can lead to frequent disruptions caused by the sounds of unrelated conversations and noise from office equipment. A good design can minimize these problems but the limitations inherent in open plan layout with regard to speech privacy must be understood by the client and the designer at the beginning of a project.

The purpose of this section of the guideline is to provide minimum specifications for the various parameters that determine the acoustical condition in an open or cellular office. Many of these parameters are interdependent which means that a deficiency in any one could seriously compromise the overall acoustical objective. For a new design, all the parameters that are described need to be considered. For remedial work, these guidelines can be used to assess the suitability of existing components in order to develop an upgrading strategy.

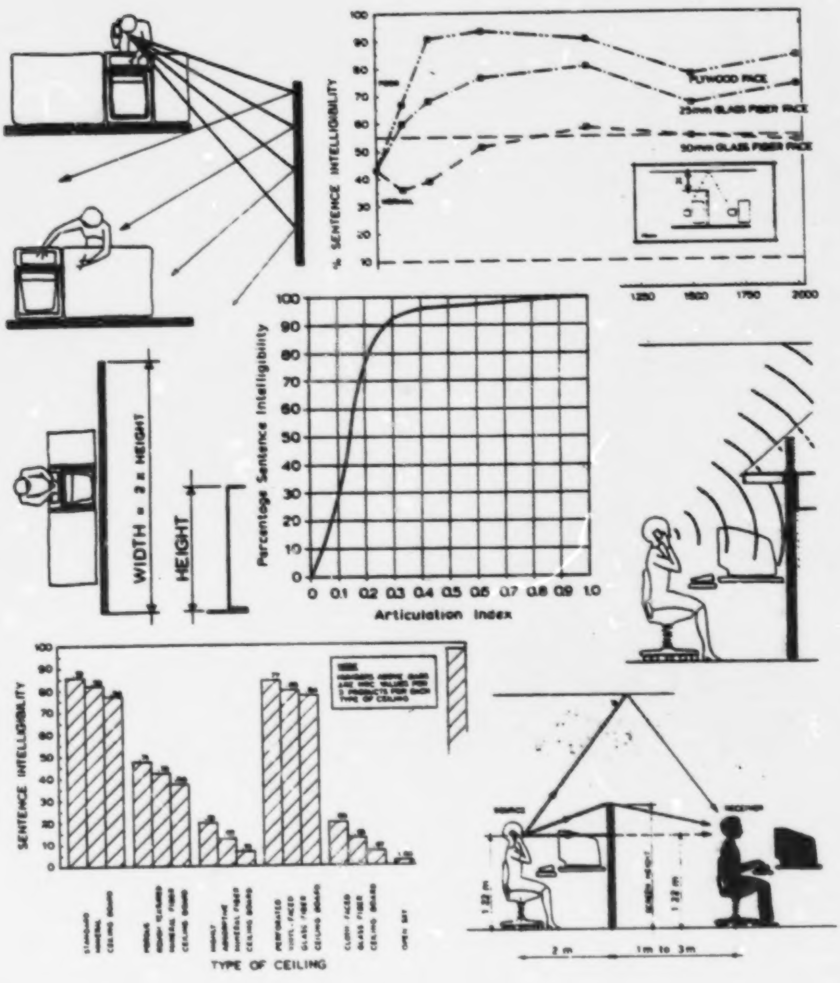
SPEECH PRIVACY

The acoustical treatment required in an office depends very much on the privacy expectations of the occupants and on the type of office provided. Most situations can be described by one of the following privacy categories.

Open Plan Space:

- Level 1: Normal Privacy - Between Departments

  In the most basic open plan situation, office workers require a space that allows communication to occur between nearby workstations but effectively


% SENTENCE INTELLIGIBILITY
100
90
80
70
60
50
40
30
20
10
PLYWOOD FACE
25mm GLASS FIBER FACE
50mm GLASS FIBER FACE
H
1250
1500
1750
2000
Percentage Sentence Intelligibility
100
90
80
70
60
50
40
30
20
10
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1.0
Articulation Index
WIDTH = 2 x HEIGHT
HEIGHT
SENTENCE INTELLIGIBILITY
100
90
80
70
60
50
40
30
20
10
0
STANDARD MINERAL CEILING BOARD
MEDIUM HIGHLY FISSURED MINERAL FIBER CEILING BOARD
HIGHLY ABSORPTIVE MINERAL FIBER CEILING BOARD
PERFORATED VINYL-FACED GLASS FIBER CEILING BOARD
CLOTH FACED GLASS FIBER CEILING BOARD
OPEN SKY
TYPE OF CEILING
SOURCE
RECEIVER
1.22 m
SCREEN HEIGHT
1.22 m
2 m
1m to 3m

isolates one branch or department from another. The acoustical design basically consists of providing a very sound absorptive ceiling and tall screens surrounding each working unit. Office noise will diminish very quickly with distance under these conditions. If the privacy zones are large, then very little distraction will be caused by activities taking place in other areas.

This type of office performs best when all groups create some noise through their work activity. Ideally this will result in a reasonably constant ambient noise level throughout the office. However, dissatisfaction will be encountered if there are only a few particularly loud groups or individuals. They will be heard above all else since there is no continuous din to mask the disruptive intermittent noise. In this respect, an open plan office can certainly be too quiet. For most situations sufficient background noise is typically provided by numerous sources, such as general office activity, the mechanical system, traffic, desk top fans and so on.

- Level 2: Normal Privacy - Between Workstations

  The majority of office workers require at least a minimal level of privacy between adjacent workstations. Conversations from nearby that are occasionally understood will not present a problem but confidentiality should be possible by lowering voice levels. The amount of distraction in this type of office will be acceptable to most unless the nature of the work involves extreme concentration.

  The key elements, in addition to a very sound absorptive ceiling and moderately high screens, include an electronic sound masking system and a carefully planned workstation layout. The proper orientation of people within the office will minimize the level of speech propagating between workstations. A masking system will ensure that there is always sufficient ambient noise present to reduce the intelligibility and associated distraction of speech that cannot be prevented from spilling over from one workstation to the next.

- Level 3: Confidential Privacy

  Confidential privacy at conversational voice levels is possible in an open plan office, but it is difficult to achieve and even more difficult to maintain. This degree of privacy requires that all architectural components are optimized including the use of tall screens and sound masking. In addition, the talker and inadvertent listener must both be seated on opposite sides of a screen and separated by at least 3 m. It is, of course, not usually possible to maintain this orientation and consequently privacy can be lost at any time. An exception may occur when it is feasible to provide unusually large workstations surrounded by unoccupied buffer zones. Space limitations will usually prohibit this except for top ranking employees. This kind of office environment is generally suitable for those who benefit from confidential speech privacy but do not consider this to be an essential requirement.

Combined Space, Open + Cellular:

It may not always be practical or desirable to have an office that is predominantly open plan. Designs that offer a mixture of open and cellular space have different acoustical design requirements from the large open plan office.

Workers that require optimum privacy conditions are generally placed in cellular offices. The most important architectural elements are the partition and ceiling systems since they must provide adequate sound isolation.

The open plan space tends to be divided into many small areas made up of only a few workstations. Privacy within each area is not typically a concern but it should exist between the different open plan areas. Cellular offices can be effectively used as acoustical barriers for this purpose.

Screens or workstation panels are primarily intended to provide visual privacy but a layout that promotes speech privacy should be used. The suspended ceiling and screen surfaces should be moderately sound absorptive to control general activity noise.

EQUIPMENT NOISE

As the open areas become larger and the density of workers increases, the number of problems associated with office equipment noise also escalates. Ringing phones, typewriters and impact printers are the most common sources of annoyance. The best noise abatement technique is to select inherently quiet equipment or alternatively to use optional sound isolating hoods and enclosures provided by the equipment manufacturer. The subjective impact from noisy pieces of equipment can be further reduced by locating it near the people who will use it most often. In cases where this is not convenient, consideration should be given to providing fully enclosed rooms or remote areas surrounded by tall screens.

OPEN PLAN OFFICE SPACE

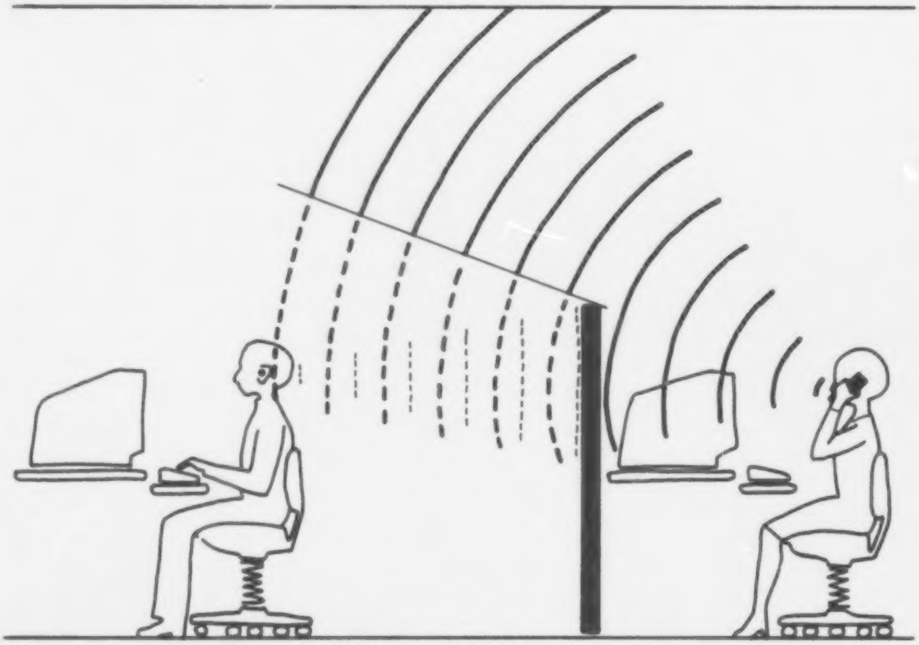
SCREENS

1.0 Sound propagates between workstations by diffraction around and over the screen as well as by transmission through the screen. Use the tallest screen possible consistent with other requirements. The Sound Transmission Class and screen or panel height shall meet the stated criteria.

CRITERIA: NORMAL PRIVACY: STC: ≥ 20
PANEL HEIGHT: ≥ 1.5m

CONFIDENTIAL PRIVACY: STC: ≥ 20
PANEL HEIGHT: ≥ 1.8m

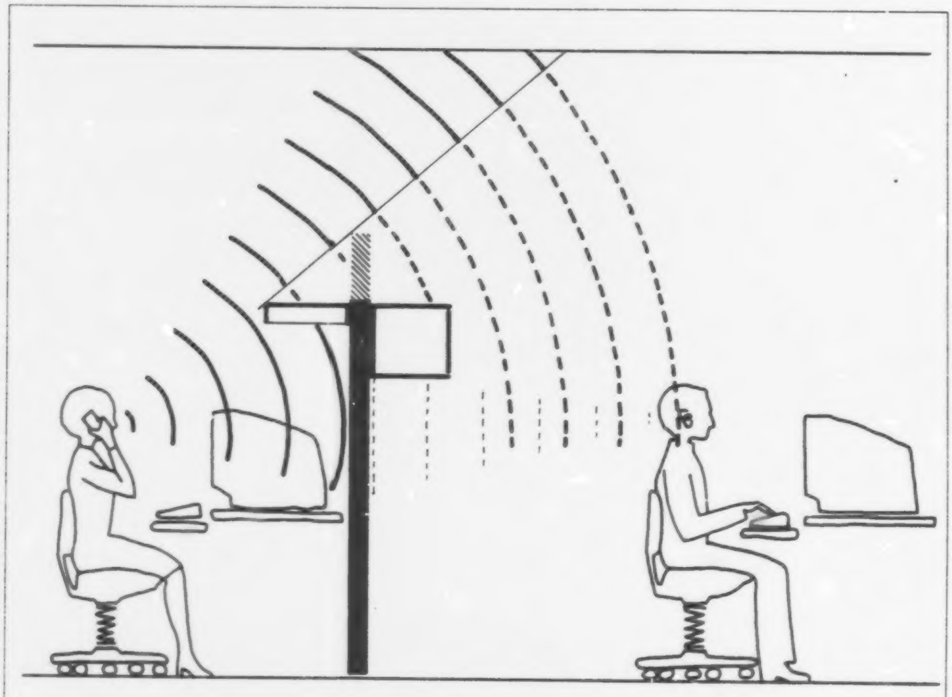
(PRODUCT MEASUREMENT)



EFFECT OF SCREENS ON SOUND TRANSMISSION

2.0 Effective height can be increased by providing shelving or other workstation components near the top of the screen.

(PRODUCT MEASUREMENT)



EFFECT OF SHELVING NEAR TOP OF SCREEN

3.0 The screen system shall be capable of providing a width of at least twice the height. Gaps between panels shall be minimized by providing tight butt joints.

(PRODUCT MEASUREMENT)

4.0 Gaps below screens can reduce privacy and shall be limited.

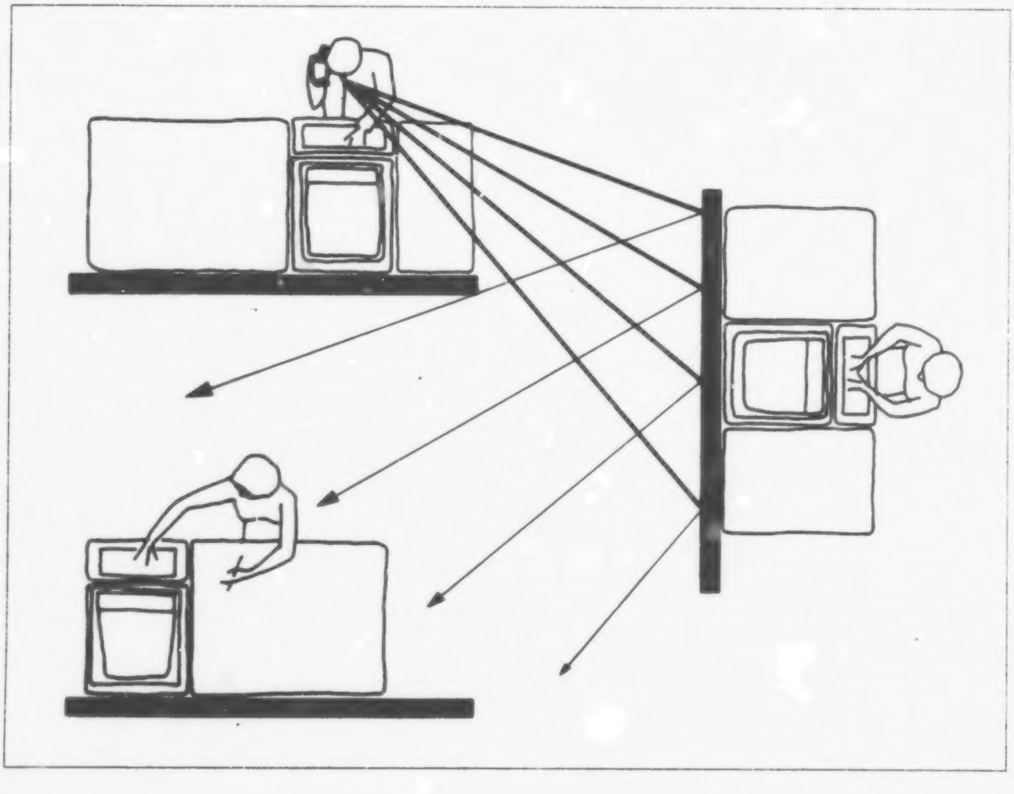
CRITERIA:	For Normal Privacy Screen:	50 mm
	For Confidential Privacy Screen:	25 mm

(PRODUCT MEASUREMENT)

5.0 Screen or panels can reflect sound from one workstation to another. All vertical panel surfaces shall be designed to minimize the effect of these reflections. Minimum acceptable absorption coefficients vary with frequency.

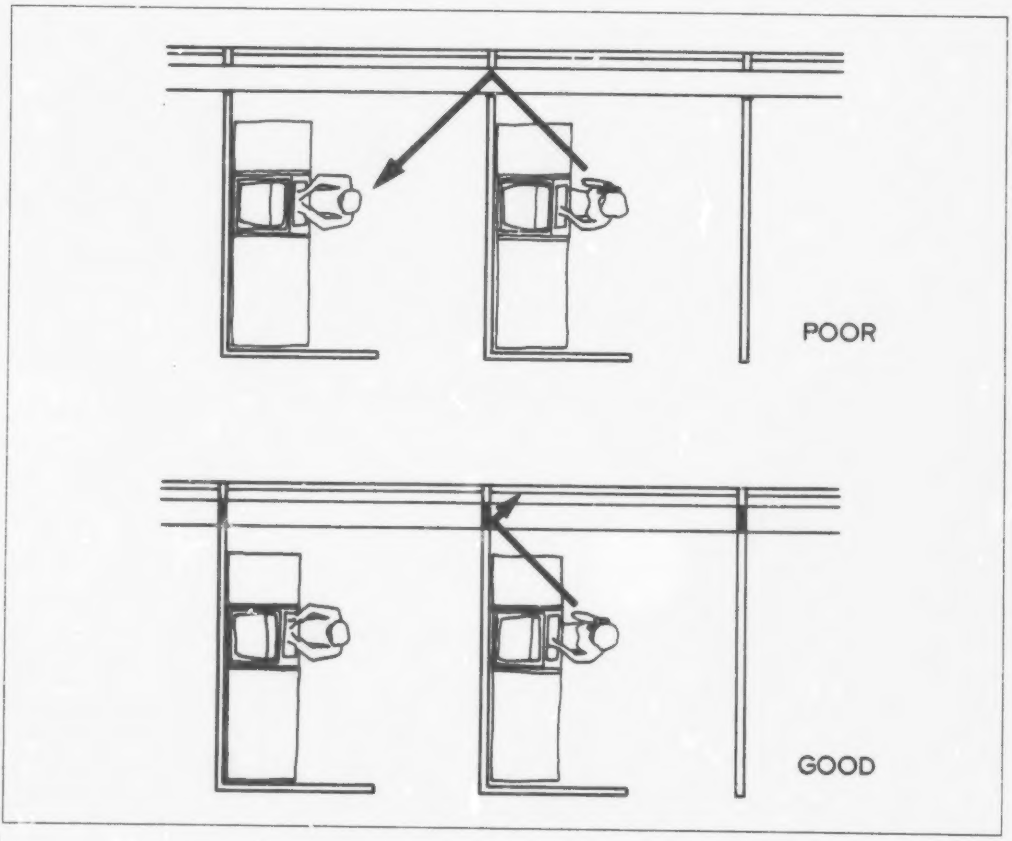
CRITERIA:	Frequency	Minimum Absorption Coefficient
	250 Hz	0.20
	500 Hz	0.50
	1000 Hz	0.85
	2000 Hz	0.85
	4000 Hz	0.85

(PRODUCT SPECIFICATION)



6.0 Sound reflecting surfaces may include windows when workstations are positioned along the perimeter of the building. In these situations, tight fitting filler panels should be provided to block any openings between the edge of the workstation and the glass or window mullion.

(VISUAL INSPECTION)



ACOUSTIC WALL PANELS

7.0 Large wall surfaces or large rectangular columns that may reflect sound between workstations should be covered with sound absorptive panels with acoustic requirements similar to panel surfaces (Clause 5.0).

(PRODUCT SPECIFICATION)

CEILING ABSORPTION

8.0 Assuming the screen has sufficient height, width and an adequate STC rating, the most significant path for speech propagating between workstations is the reflection from the ceiling system. Minimum criteria vary with speech privacy requirements. The Noise Reduction Coefficient (N.R.C.) is not recommended for use as a guideline.

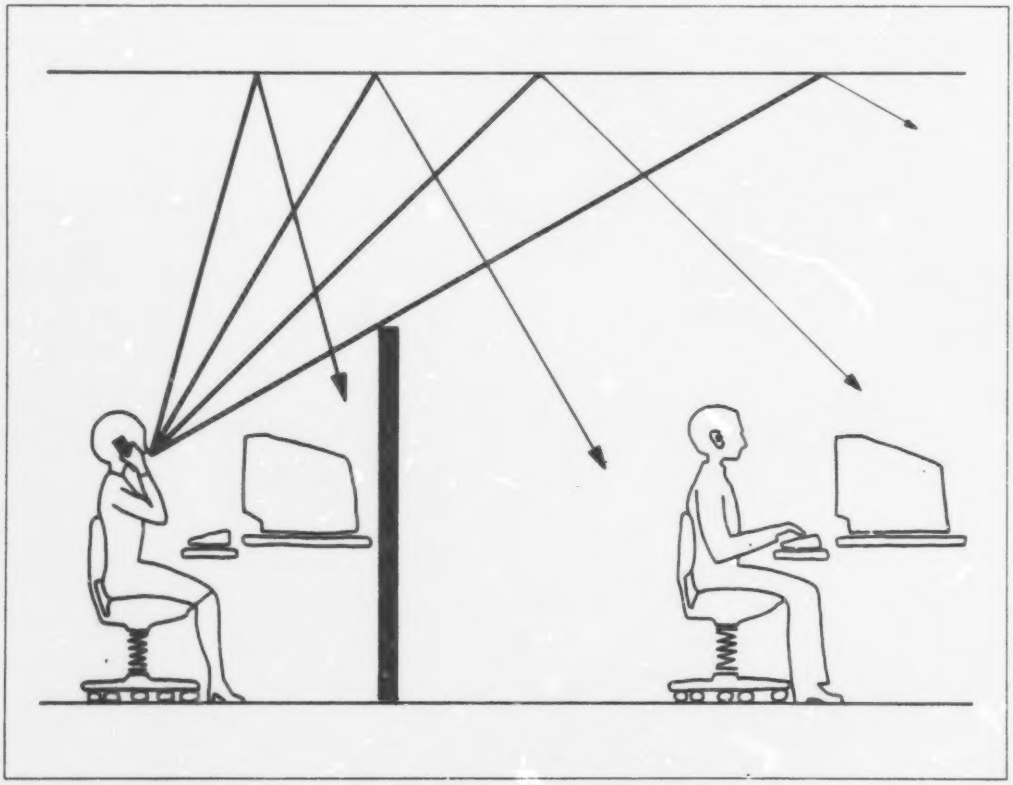
CRITERIA: **NORMAL PRIVACY:** NIC′ ≥ 18

or

Frequency	Minimum Absorption Coefficient
250 Hz	0.50
500 Hz	0.60
1000 Hz	0.95
2000 Hz	0.95
4000 Hz	0.95

CONFIDENTIAL PRIVACY: NIC′ ≥ 21

(PRODUCT SPECIFICATION)



9.0 Luminaires can reduce the benefits of an otherwise good ceiling. Parabolic and deep egg crate type lenses generally have a small dettimental effect on normal privacy and should be used whenever overhead lighting is necessary. Indirect and task lighting are preferred for optimum acoustic conditions.

(CONSTRUCTION SPECIFICATION)

10.0 Avoid *continuous* rows of lighting.

(DESIGN CONSIDERATION)

11.0 Large rectangular or round air diffusers can reduce privacy in localized areas. Use air troffers which are integral part of light fixture. Minimize surface area of sound reflective elements.

(DESIGN CONSIDERATION)

CEILING TRANSMISSION LOSS

12.0 The transmission of sound through the ceiling system must be considered where there is a mix of open and cellular office space. The STC requirements for the ceiling depend on the level of ambient noise and the desired degree of privacy.

At moderate sound masking levels, 43-46 dB(A), the ceiling shall have a minimum two-pass STC rating to provide a confidential degree of privacy for *slightly lowered or normal* voice levels.

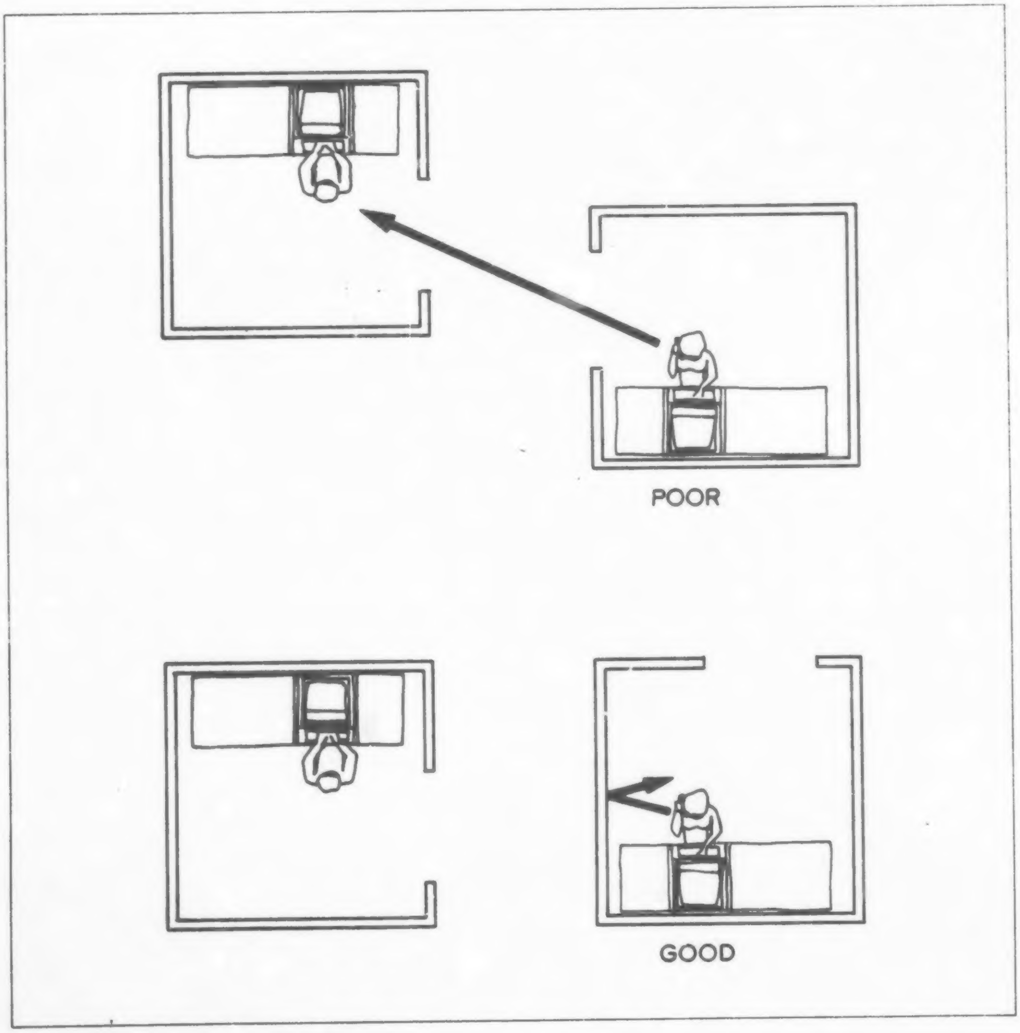
CRITERION: STC = 20 - 24

(PRODUCT SPECIFICATION/VISUAL INSPECTION)

13.0 At moderate sound masking levels, 43-46 dB(A), the ceiling shall have a minimum two-pass STC rating to provide a confidential degree of privacy for *slightly raised* voice levels.

CRITERION: STC = 30 - 34

(PRODUCT SPECIFICATION/VISUAL INSPECTION)



MASKING

14.0 Electronic sound masking shall be provided where privacy is required between adjacent workstation or where distraction is to be minimized.

(VISUAL INSPECTION)

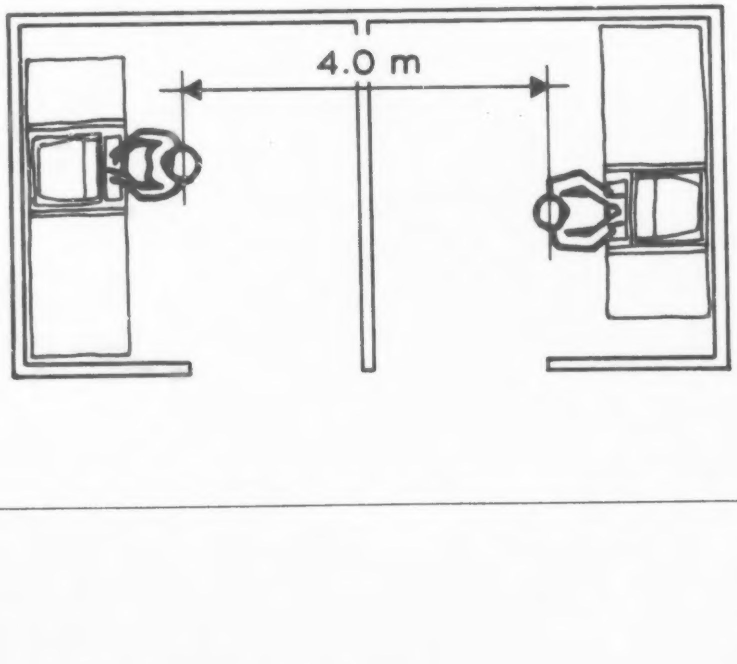
OFFICE PLANNING

15.0 The workstation layout has a large influence on speech privacy. Line of sight between office workers shall be avoided.

(FLOOR PLAN EVALUATION)

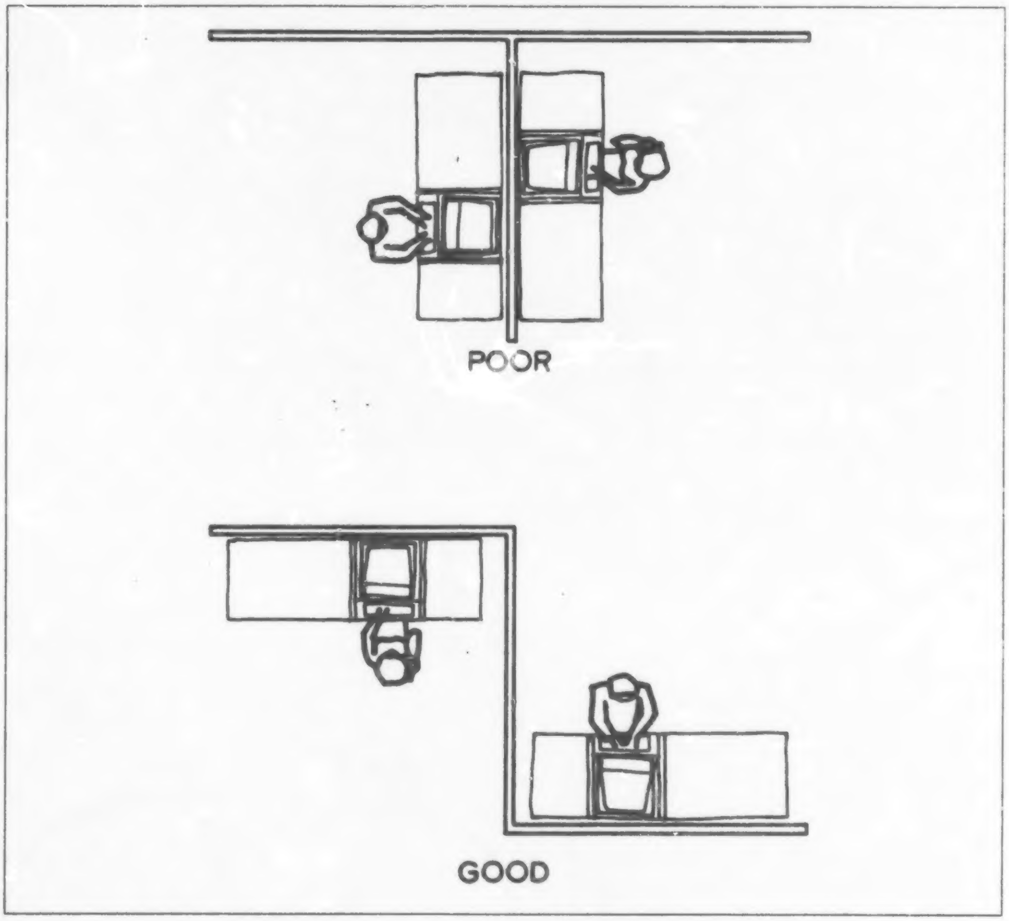
16.0 Minimum separation between people of 4.0 m should be provided, where feasible.

(FLOOR PLAN EVALUATION)



17.0 The workstation and its furniture shall be positioned in such a way that people do not face each other in their usual working position. When possible, people shall be positioned back to back.

(FLOOR PLAN EVALUATION)

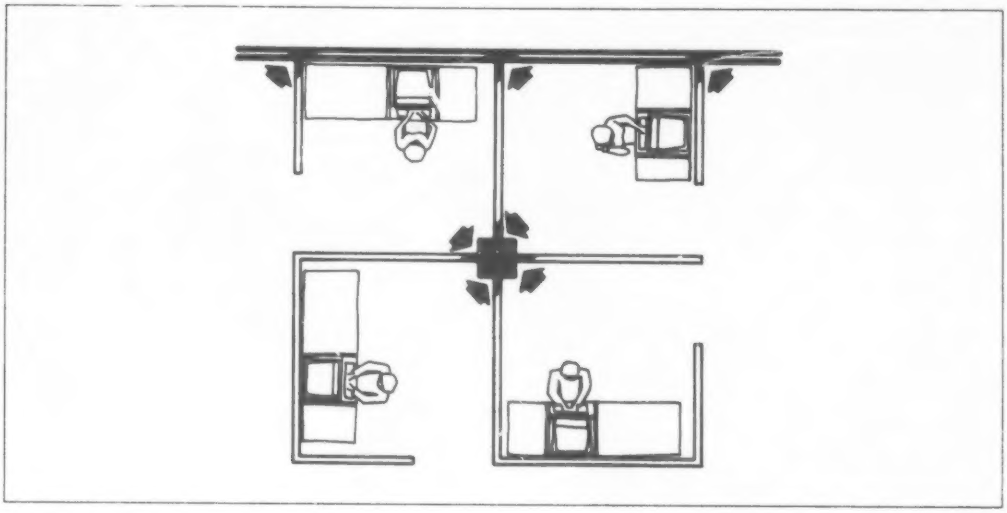


18.0 Workers shall be placed as close as possible to a sound absorptive surface and furniture shall be arranged so that the acoustical surface is in line with the direction of the speaker's voice.

(FLOOR PLAN EVALUATION)

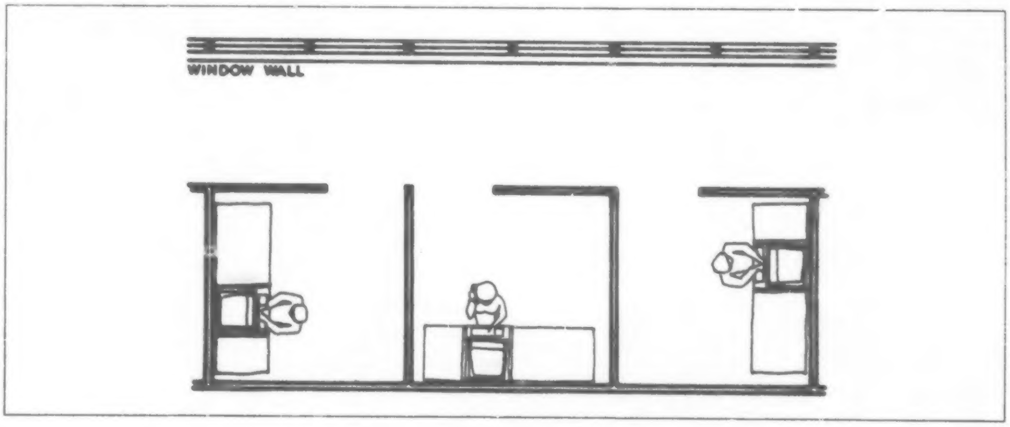
19.0 Screen ends shall be placed tight against columns, walls and any vertical surface that reflects sound.

(VISUAL INSPECTION)



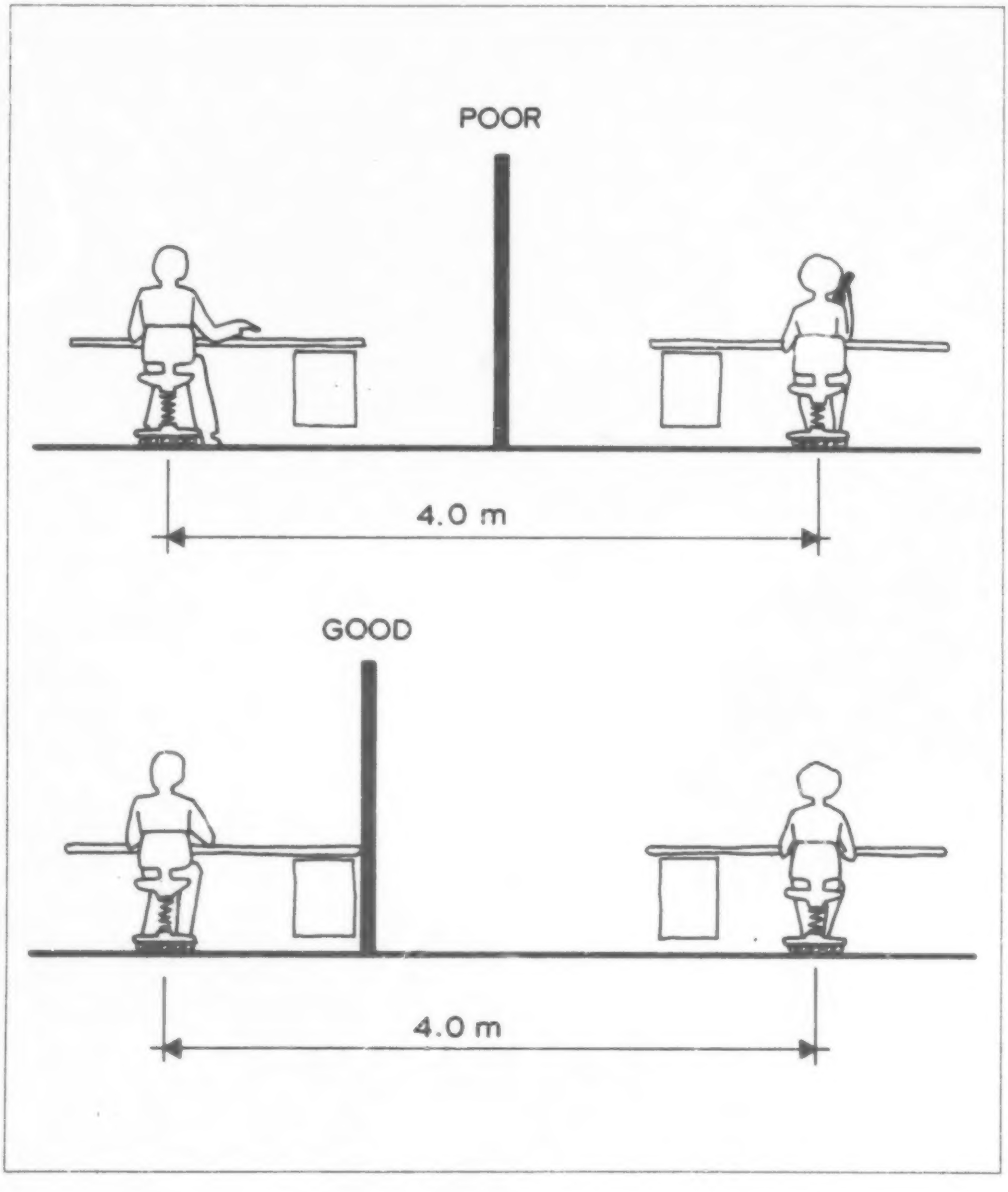
20.0 Whenever possible, glazed walls shall be used as aisles to avoid difficulty of fitting screen to windows.

(FLOOR PLAN EVALUATION)



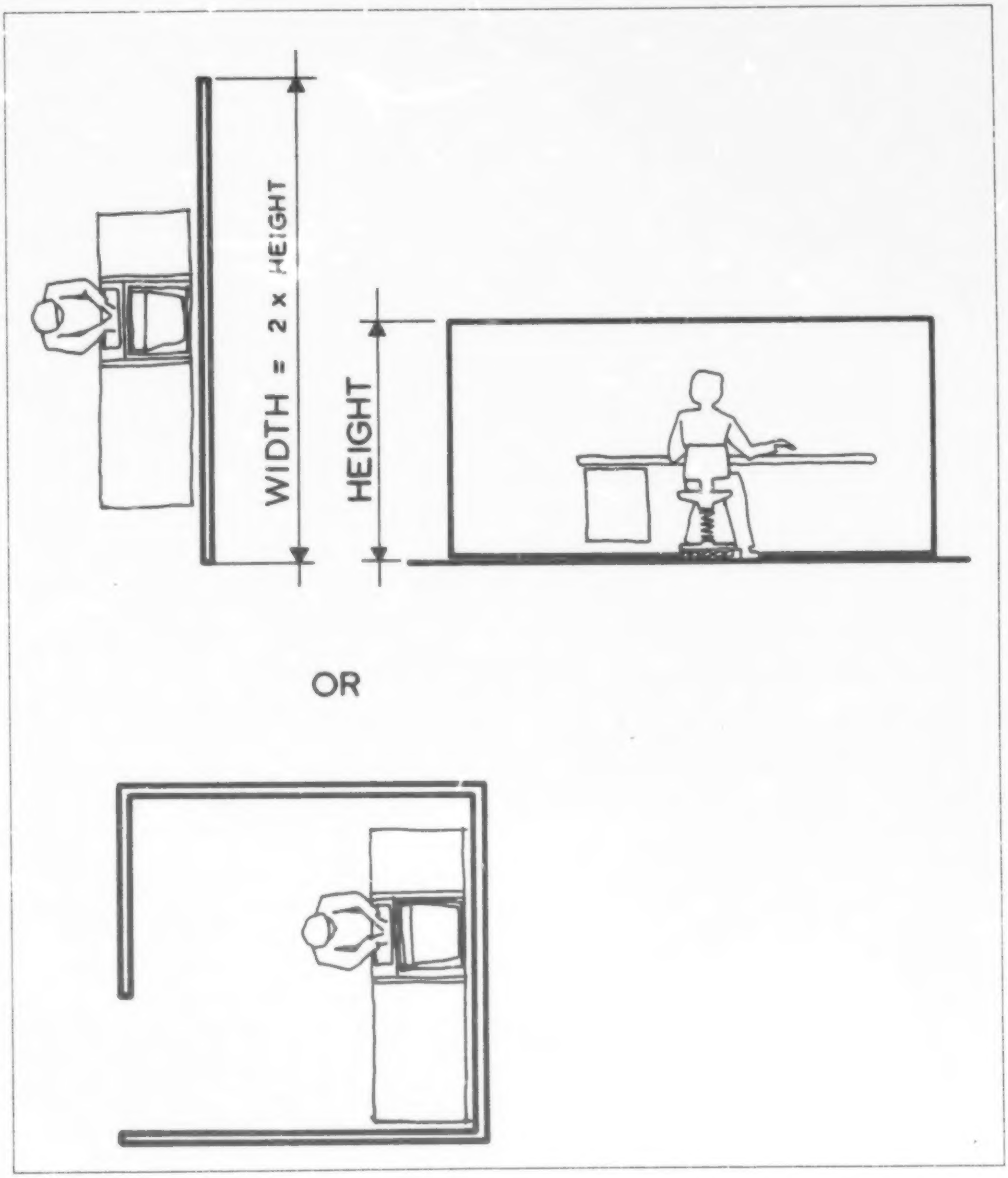
21.0 Whenever possible, screens dividing two workplaces shall be placed closer to one occupant.

(FLOOR PLAN EVALUATION)


POOR
4.0 m
GOOD
4.0 m

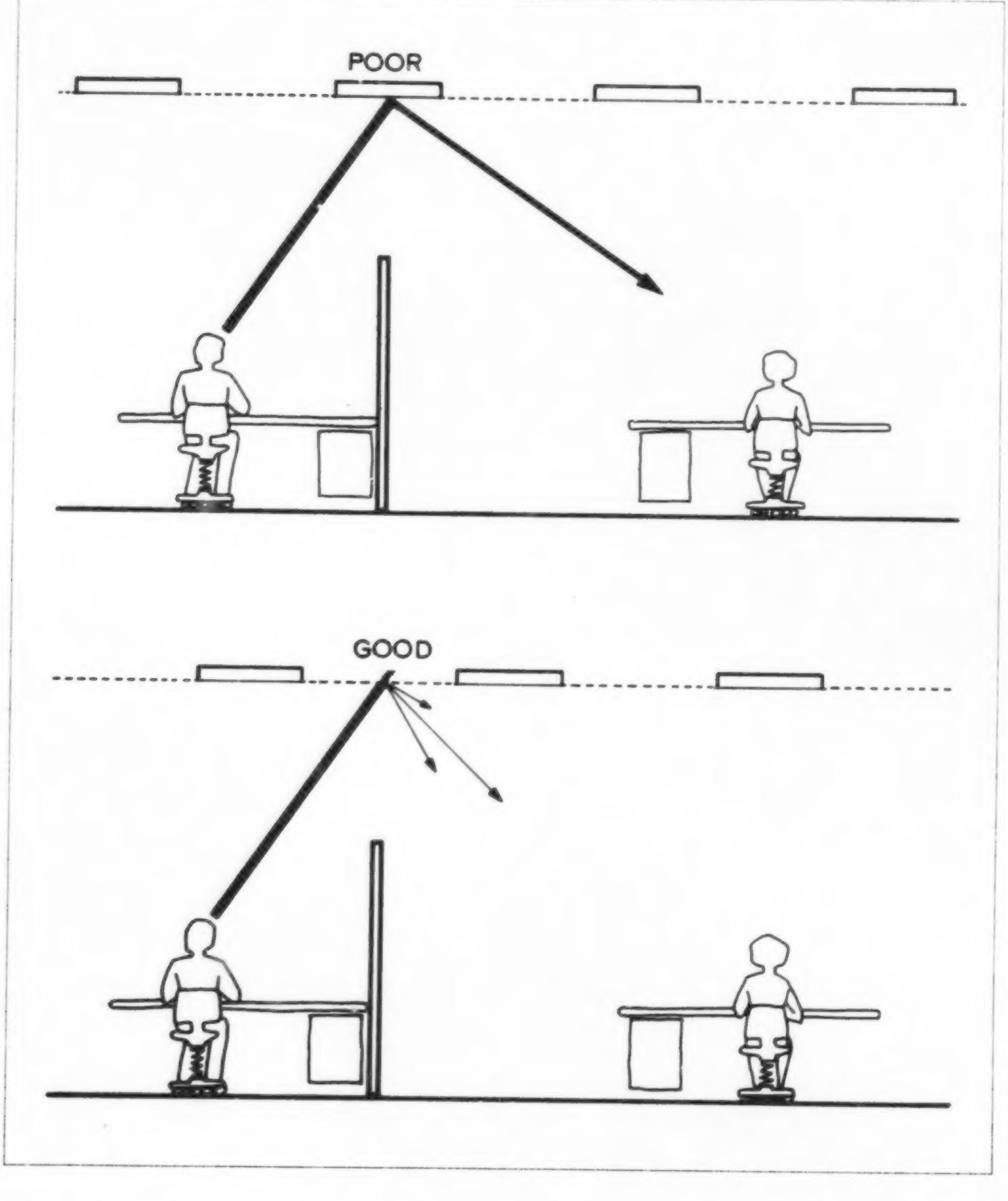
22.0 Use screens to enclose workstation on three sides or provide screen width that is twice the height.

(PRODUCT SPECIFICATION/VISUAL INSPECTION)


WIDTH = 2 x HEIGHT
HEIGHT
OR

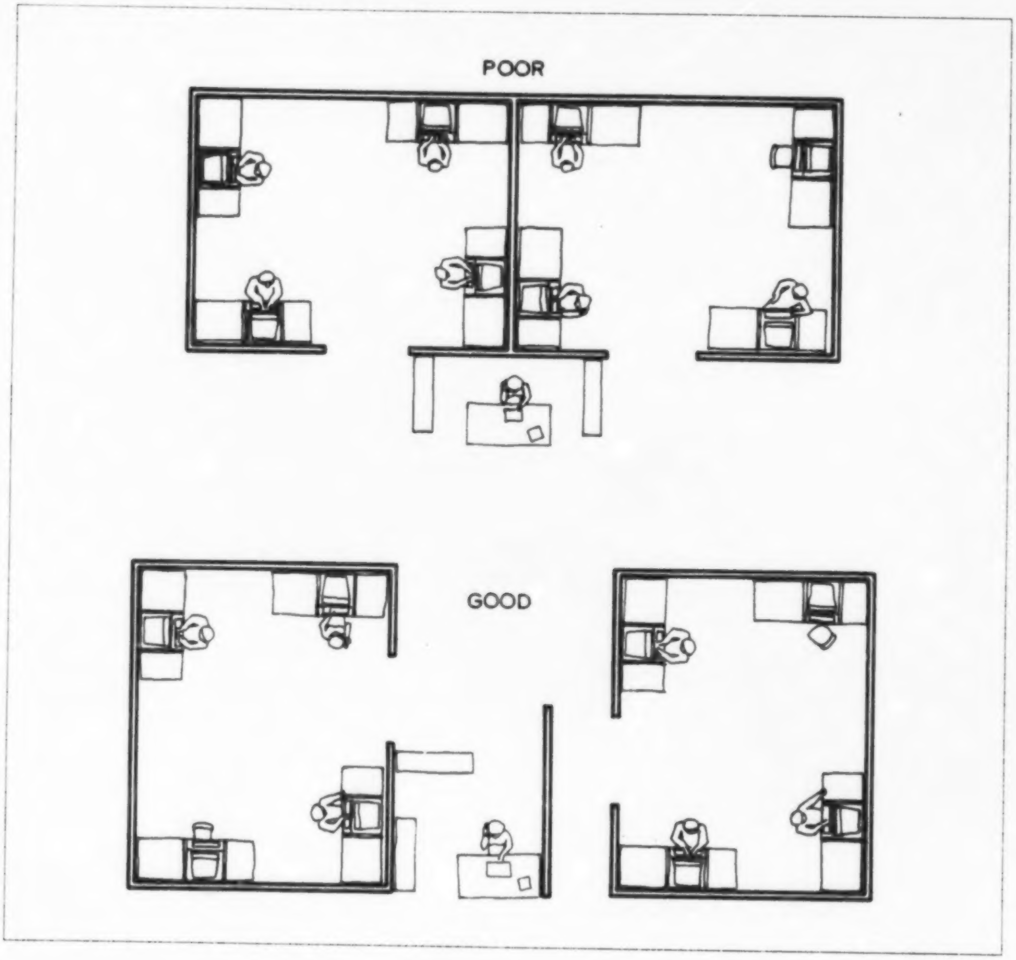
23.0 Placing screens directly below rows of luminaires shall be avoided. (See Lighting Section)

(FLOOR PLAN EVALUATION)



24.0 Use acoustically non-critical space as a buffer zone between working groups.

(FLOOR PLAN EVALUATION)



25.0 Noisy operations shall be separated from quiet ones and specially treated areas shall be provided for noisy equipment.

(FLOOR PLAN EVALUATION)

26.0 Provide maximum ceiling height possible.

(VISUAL INSPECTION)

COMBINED OFFICE SPACE (OPEN + CELLULAR)

Where there is a high ratio of cellular to open office space, the requirements for many parameters differ from the open plan design; for instance the location and type of luminaires is not important from an acoustic point of view. The other acoustical guidelines are modified.

SCREEN

27.0 Screens or workstation panels shall be high enough to provide visual privacy.

(VISUAL INSPECTION)

28.0 Screens or workstation panels shall be sound absorptive to control activity noise (See Clause 5.0).

(PRODUCT MEASUREMENT)

CEILING ABSORPTION

29.0 Ceiling shall have a minimum Noise Reduction Coefficient to control activity noise.

CRITERION: NRC $\geq$ 0.60

(PRODUCT MEASUREMENT)

CEILING TRANSMISSION LOSS

30.0 Offices with no electronic masking but with noticeable mechanical noise and constant activity noise require a ceiling with a minimum STC rating to achieve a confidential degree of privacy between adjacent offices when a normal voice effort is used.

CRITERION: STC = 40 - 44

(VISUAL INSPECTION)

31.0 In a quiet office environment, it is not likely that a continuous suspended ceiling will provide adequate sound isolation for confidential privacy. Construction of walls shall be slab to slab or include a plenum barrier.

(CONSTRUCTION SPECIFICATION)

PARTITIONS

32.0 Partition systems shall provide a minimum STC to achieve privacy between adjacent offices.

CRITERION: STC = 45

(PRODUCT SPECIFICATION)

33.0 Sound flanking around perimeter of partitions and through convector cabinet shall be controlled.

(VISUAL INSPECTION/CONSTRUCTION SPECIFICATION)

MASKING

34.0 The use of central electronic sound masking is not required.

(VISUAL INSPECTION)

OFFICE PLANNING

35.0 Workstation layout shall be optimized (See Clauses 14.0 - 24.0).

36.0 Whenever possible, locate cellular offices to separate acoustically the open plan space of different working groups.

REFERENCES

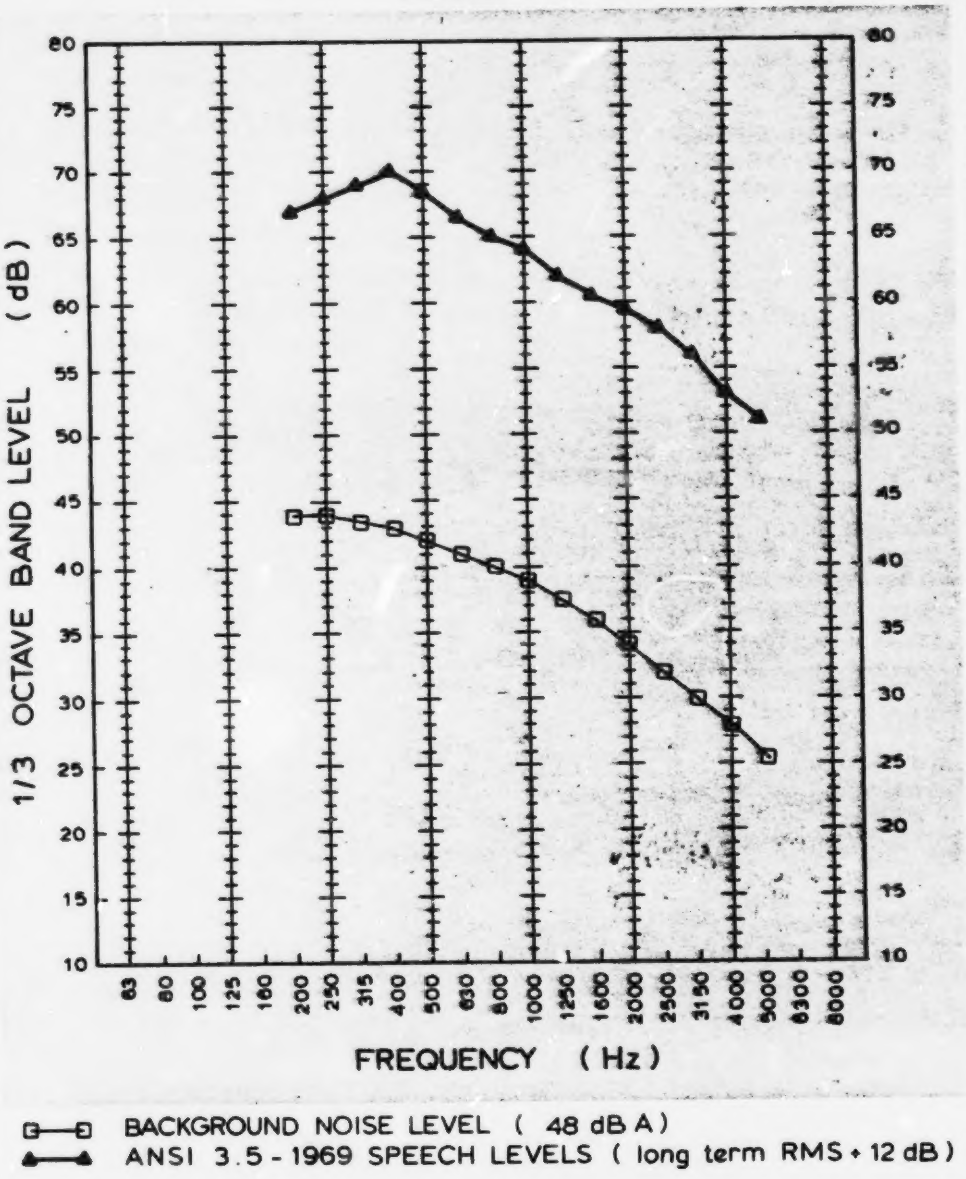
1. S.T.C. - ASTM E90 "Recommended Practice for Laboratory of Airborne Sound Transmission Loss of Building Partitions"
   - ASTM E413 "Determination of Sound Transmission Class".

2. **Absorption Coefficients**
   - ASTM C423 "Sound Absorption of Acoustical Materials in Reverberation Rooms".

3. S.T.C. - AMA I-II - 1967 "Ceiling Sound Transmission Test by Two-Room Method"

4. NIC′ - General Services Administration, Public Buildings Service "Acoustical System Performance for Office Space", PBS C.2

FIGURE 1



MASKING AND SPEECH SOUND LEVELS
dB re 20 micro-Pa

BASES FOR PERFORMANCE REQUIREMENTS

SPEECH PRIVACY

Speech privacy occurs when a conversation heard by an inadvertent listener is similar in loudness to the ambient noise to which the listener is simultaneously exposed. In order to predict the degree of privacy for a specific situation, it is necessary to first determine the following: speech characteristics of the talker; attenuation of speech sounds between talker and listener; and the masking noise characteristics at the listener's location. A descriptor commonly used to account for these variables is the Articulation Index (A.I.). Basically, the A.I. is determined by applying a frequency dependent weighting to the speech signal-to-noise ratio in a manner that corresponds to intelligibility. The result is a single number which is proportional to privacy.

Due to the many possible combinations of these variables, it is convenient to standardize the voice and masking characteristics. Privacy is then determined by considering the sound isolation between talker and listener as the only variable.

Speech Levels

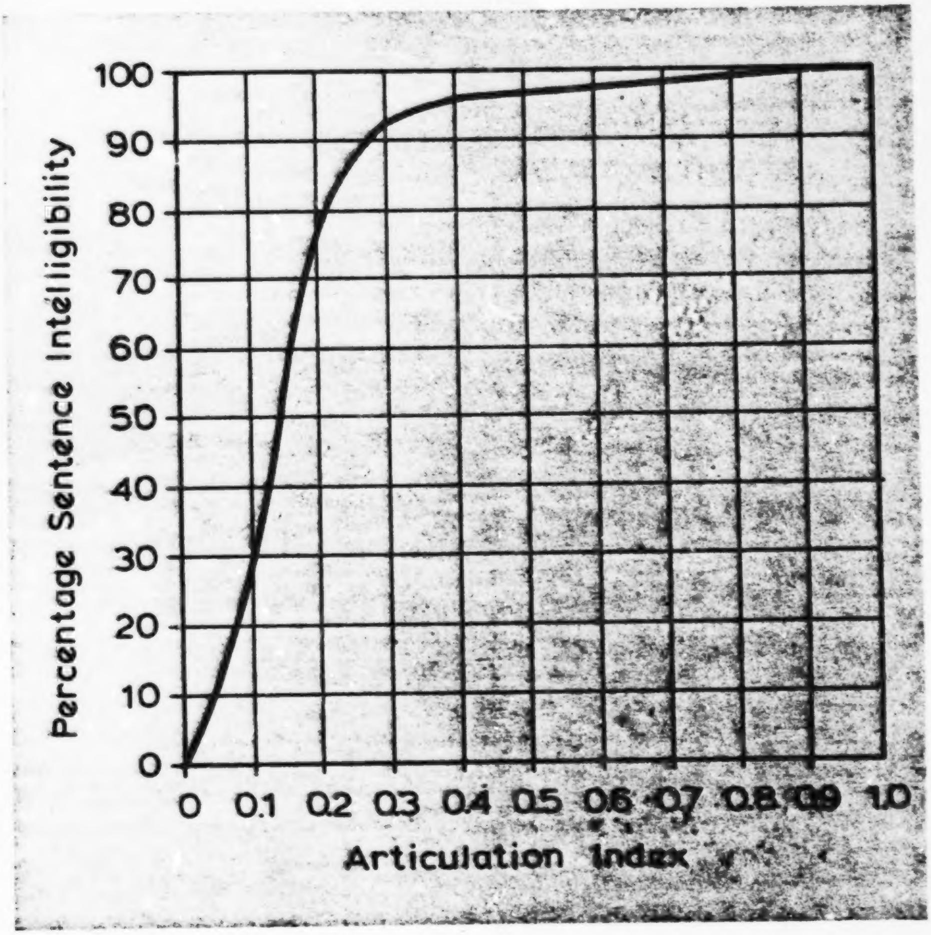
Speech can vary a great deal from one person to the next, but attempts have been made to establish the characteristics of a typical voice. The spectrum indicated in Figure I, represents a male voice at a normal level of conversation measured at a distance of approximately 1 m(1). A lowered voice effort assumes the same spectral distribution at a level of 6 dB below the normal voice. Similarly, a raised voice is 6 dB higher than that shown. Detailed information for a standard female voice spectrum is not available.

Sound Masking

Ambient noise in an office can vary a great deal when it is not intentionally generated for masking purposes. Noise due to the mechanical system, for example, will change with location, selection of equipment, cooling loads and so on. The variability is so large that any generalization is not very meaningful. None the less, this "natural" source of masking is often all that is provided in many open plan offices and the results are generally acceptable if privacy is only required over large distances.

An electronic masking system is the preferable means of introducing noise into a space. A good system will provide a very uniform and constant coverage and allows the sound to be adjusted for the unique requirements of each office. The masking spectrum shown

FIGURE 2



RELATIONSHIP BETWEEN SPEECH INTELLIGIBILITY AND ARTICULATION INDEX

	A.I.	% Sentence Intelligibility
Confidential	0.00 - 0.05	0 - 10
Normal	0.05 - 0.15	10 - 55
Marginal to Poor	0.15 - 1.00	55 - 100

on Figure I has evolved as a compromise between masking effectiveness and the subjective acceptability of the sound. This spectrum will result in an unobtrusive noise that is very similar to that created by an air handling system. As shown, the overall level is approximately 48 dB(A). This is generally found to be the maximum level that office workers will tolerate. This is also about the minimum level that will result in good privacy between adjacent workstations.

Fortunately, workers tend to use a slightly lowered voice when in an open plan office and consequently a proportionately lower level of masking will still result in acceptable privacy. Ambient noise levels of approximately 43 -45 dB(A) can therefore still be reasonably effective and do not usually lead to dissatisfaction with the open office.

Central masking systems typically consist of a noise generator, equalizer, amplifier and loudspeaker network. Two or three parallel systems are often provided in order to reduce the disruption that may result from equipment failure.

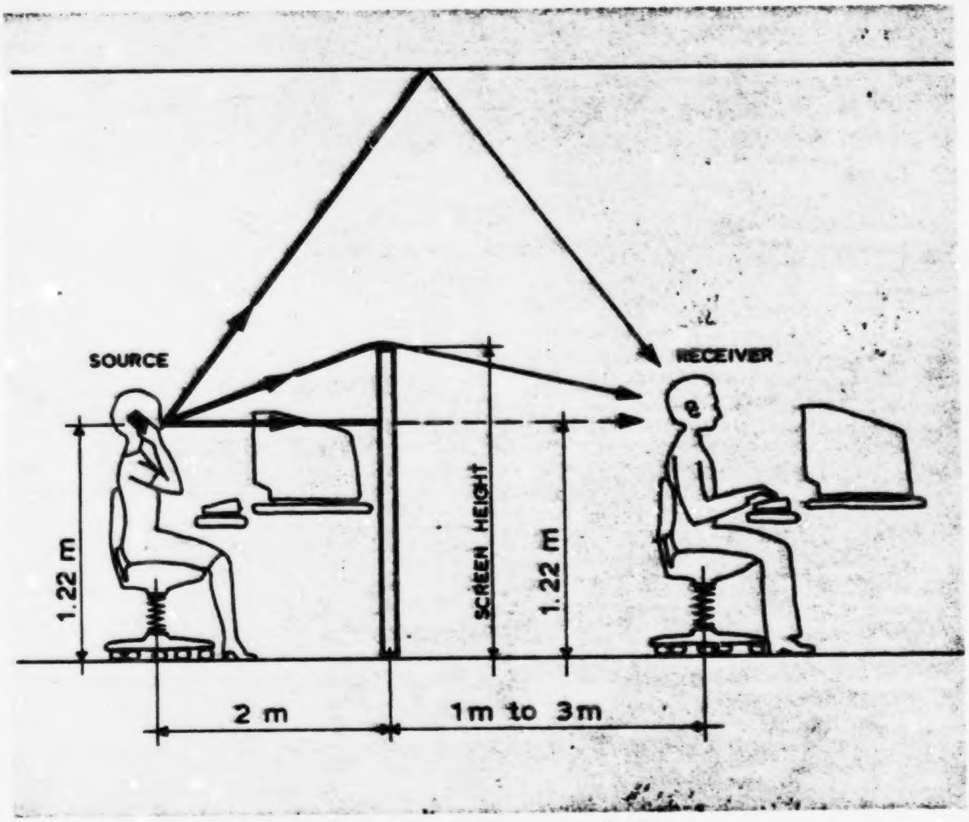
Loudspeakers are located above the suspended ceiling on approximately a 3 m square grid. The type of loudspeaker required depends on plenum depth and construction. In concrete structures, for example, the loudspeakers are generally mounted in enclosures directed toward the reflective structural slab above. This tends to distribute the masking sound more evenly throughout the occupied space. Buildings with structural steel floors are often fireproofed with materials that absorb sound very efficiently. In these cases, the loudspeakers are positioned with the primary axis parallel to the ceiling. Alternate loudspeakers, mounted on baffles, are oriented at 60° - 90° to one another, in order to maximize diffusion.

In either case, there must be a sufficient number of loudspeakers to produce a very uniform sound field so that the location of individual speakers cannot be readily detected. Fewer complaints about masking are received if workers are unaware of its presence.

Noise from other building systems must be sufficiently controlled so that the masking levels are at least 6 dB above all other sources combined. A design goal of NC 30 for mechanical noise is generally adequate. Noise radiated by mechanical equipment located in the plenum must also be carefully considered since the ceilings that are used in open plan offices allow sound to pass through with relatively little attenuation. Radiated noise data, as supplied by manufacturers, is typically corrected to account for the noise reduction provided by dense ceiling materials which are not commonly found in open plan designs. This discrepancy may result in noise levels that are 5 - 10 dB higher than expected.

Masking should be provided for most locations in a building, but cellular office space should ideally be approximately 5 dB quieter. Large conference or meeting rooms should not have any masking or highly sound absorptive finishes that are found in the open plan areas.

FIGURE 3


SOURCE
RECEIVER
1.22 m
SCREEN HEIGHT
1.22 m
2 m
1m to 3m

SCREEN DIFFRACTION LOSS $20 \log \left(\frac{\sqrt{2\pi N}}{\tanh \sqrt{2\pi N}}\right) + 5 + 20 \log \left(\frac{A + B}{R}\right)$

WHERE $N = 2 (A + B - 4) / \lambda$, λ = WAVELENGTH, $R = 1\text{m}$

SCREEN TRANSMISSION LOSS = T.L. + $20 \log \left(\frac{2 + D}{R}\right)$

CEILING REFLECTION LOSS = $20 \log \left(\frac{2C}{R}\right) - 10 \log (1 - \overline{\alpha})$, $\overline{\alpha}$ = RANDOM INCIDENCE ABSORPTION COEFFICIENT

PRIMARY SOUND PATH BETWEEN WORKSTATIONS

Degree of Privacy

Assuming that the speech and masking levels remain as shown on Figure I, or at least the relative levels remain constant, then the A.I. is calculated using predicted or measured values of attenuation between workstations following the procedure described in Reference 1. Articulation Index can then be related to the percentage of sentences understood by a listener by referring to Figure 2.

The very sharp increase in sentence intelligibility associated with small changes in A.I. is indicative of the very delicate state of privacy in an open office. For example, the A.I. can increase from 0.05 to 0.25 if the voice effort of the talker is raised from normal to loud. The corresponding increase in the percentage of sentences understood by a listener goes from 10% to almost 90%. Although it is possible to achieve a high level of privacy, it cannot be easily maintained. To assist in the design and evaluation process, the degree of privacy can be defined by the three ranges (shown in Figure 2).

ATTENUATION BETWEEN WORKSTATIONS

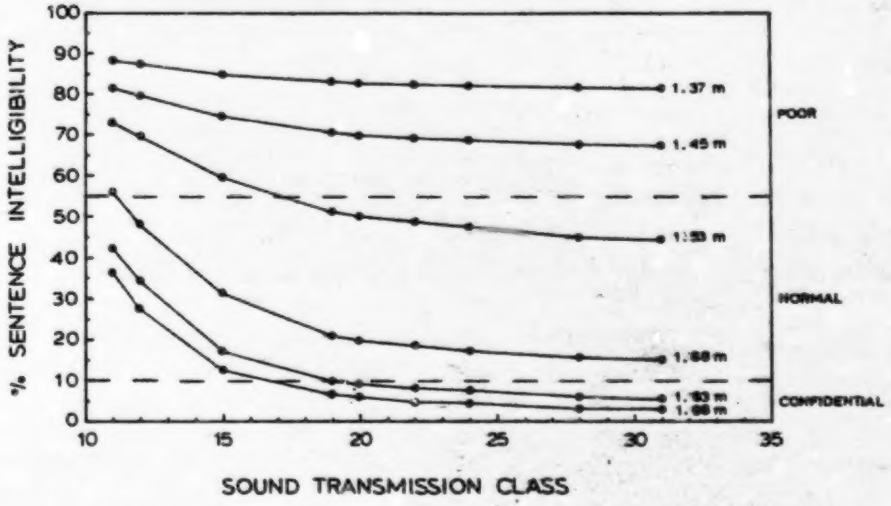
Speech propagates between workstations by the paths shown in Figure 3. There are other possibilities such as a diffracted path around the sides of the screen or a reflected path off the floor if there is a gap below the screen, but these can be controlled or eliminated rather easily. The three paths as shown have the greatest implication on the design of the office and workstation components.

The individual contribution of each path can be quantified by the formulae [2,3] (given in Figure 3). Acoustical measurements have been found to agree reasonably well with the prediction over a wide range of conditions.

The intensity of the ceiling path is primarily dependent on the reflectivity of the material at a specific angle. This variable is difficult to measure and is therefore substituted with an expression using the random incidence absorption coefficient. Absorption described in this form, is routinely measured and reported by ceiling board manufacturers.

Screens or workstation panels control the remaining two paths. Diffraction of sound over and around the screen is controlled by the dimensions and the relative location of the speaker and listener. Direct transmission through the screen is dependent on the sound transmission loss characteristics. Manufacturer's will also measure this variable and report it in terms of the Sound Transmission Class (STC).

FIGURE 4



S.I. FOR VARIOUS SCREEN HEIGHTS

CEILING: 38 mm GLASS FIBER
BACKGROUND NOISE: 48 dB (A)

The effects of parameters such as screen gap, floor gap, closely spaced reflecting surfaces, luminaires and so on, are difficult to model. Consequently, numerous tests have been conducted in open plan offices and laboratories using a layout similar to that of Figure 3. Test results referred to in the following sections are taken from Reference 4.

SCREEN REQUIREMENTS

Transmission Loss and Dimensions

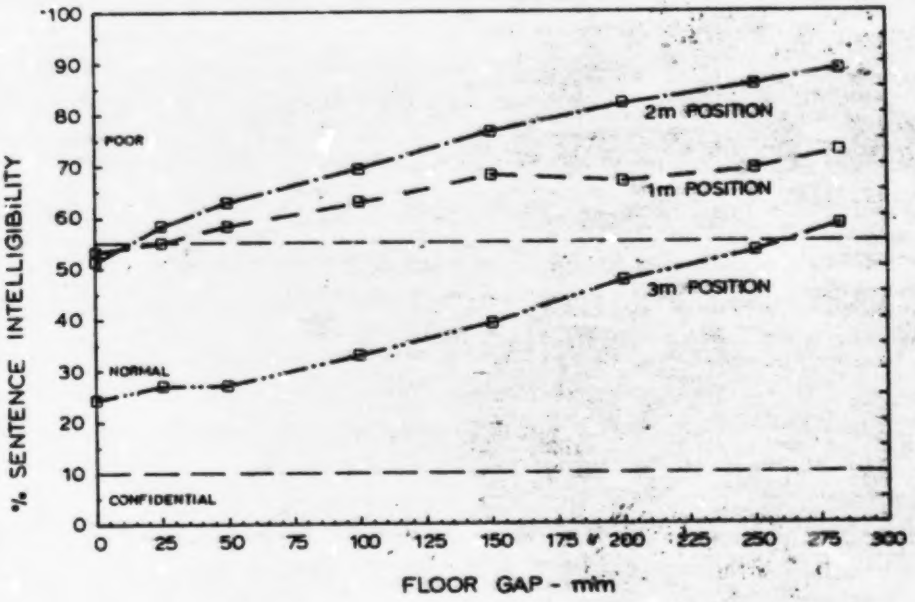
Privacy is influenced by the height and transmission loss of a screen in the manner illustrated on Figure 4. This graph is based on the prediction described previously and assumes the speaker to listener orientation of Figure 3, a normal voice effort and a 48 dB(A) masking level. The effect of the ceiling reflection is included, but, it is based on the properties of a very absorptive product so that the overall isolation is primarily dependent on the screen. Lateral diffraction is not considered since workstations are typically completely or partially enclosed on three sides. The transmission loss values used in the prediction are obtained from laboratory test data for nine screens ranging in STC from 11 to 31.

For average privacy, the screen must be a minimum of approximately 1500 mm high with an STC of 20. A screen that is much lower will not even provide visual privacy, assuming a seated position for office workers. Increasing the transmission loss of low screens beyond 20 will not result in a large subjective improvement, since overall attenuation is limited by diffraction of sound over the screen.

Privacy improves dramatically as the screen height is increased. With the ideal conditions assumed in this prediction, confidential privacy can be obtained with screens higher than approximately 1800 mm. At this height, an STC rating of 20 is still adequate since diffraction remains the dominant path. If the talker is positioned nearer to the screen than the 2 m assumed here, there is a slight improvement in privacy when the STC of tall screens is increased to approximately 24 or more.

The STC of a screen is primarily determined by the transmission loss properties of the screen septum. In general, an impermeable material with a density of approximately 2.4 kg/m^3 is sufficient for even the tallest screens[2]. Typically a 3-4 mm thick hardboard is used. To maximize the effectiveness, care must be taken to ensure that the septum is continuous or that any internal joints are well fitted and sealed. The STC test is very sensitive to any openings and will easily identify products with this problem.

FIGURE 5



EFFECT OF GAP BELOW 1.53 m HIGH SCREEN

Since it is often desirable to keep screens as low as possible for non-acoustical reasons, transparent panels can be used to increase screen height^2. Privacy will be improved where necessary and daylight and vision will not be severely restricted. Alternatively, the effective screen height can be increased by the addition of a cap to the top of the screen. This cap can be provided in the form of shelving, light valances or storage enclosures. For example, a 300 mm shelf added to the top of a 1 600 mm high screen will typically have the same diffraction loss as an 1 800 mm screen.

Floor Gap

Openings below the screen can reduce privacy although their importance is not as significant as might be expected. Desks and office furniture partially shield this opening and a carpeted floor provides further attenuation. Test results indicating the effect of the floor gap, without office furniture are shown on Figure 5. A separation of 50 mm for low screens is acceptable provided that the floor is carpeted. It is generally accepted that a 25 mm gap should not be exceeded when tall screens are used.

Screen Gap

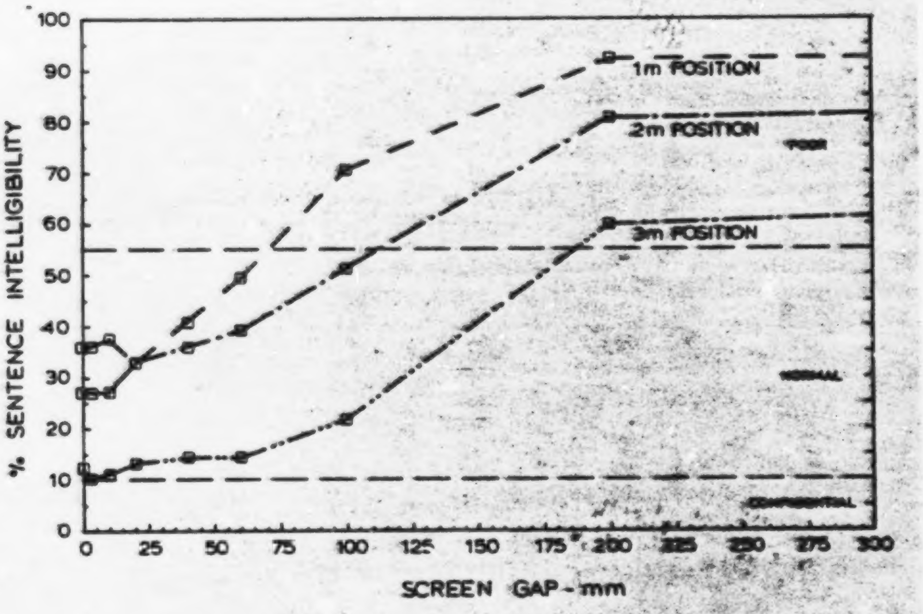
Vertical gaps between panels have a surprisingly small effect on performance as indicated by the test results shown on Figure 6. For this test, the source loudspeaker and the receiving microphone were directly in line with the gap between two 65 mm thick screens. This graph suggests that even a 25 mm gap is not too serious for normal incidence sound. However, any degradation of visual privacy is an equally important consideration. Vertical gaps should therefore be minimized by providing tight butt joints between panels. There does not appear to be any need to apply gasketing or similar measures.

Absorption of Screen Surface

Office furnishings are sometimes positioned so that sound can be reflected between work stations by a screen or a long bare wall. The importance of this reflection for three different surface finishes is indicated on Figure 7. The separation between the reflecting surface and the edge of the screen separating the talker and listener varies from a closed workstation (0 mm separation) extending to the width of a typical aisle way.

The plywood surface is nearly as reflective as a painted gypsum board wall or glazing. A very significant reduction of privacy results because of the lateral reflection from this surface. Replacing the finish with a rigid glass fibre board improves the situation considerably (particularly with the 50 mm thick material). However, for practical purposes, a maximum thickness of 25 mm is usually used for constructing acoustic wall panels and screen surfaces. The thinner treatment is certainly not ideal but preferable to a highly reflective untreated surface.

FIGURE 6



EFFECT OF VERTICAL GAP BETWEEN 1.83 m HIGH SCREEN

Similar tests assessing the effect of blinds and curtains, indicate that only a very small improvement is offered by these common window treatments[2]. Where workstations abut an exterior window wall, it is necessary to provide filler panels extending from the screen to the window mullion or glass. The separation of approximately 100-300 mm that is often encountered at this location is likely to reduce privacy to a negligible level.

Office layouts that facilitate lateral reflections between workstations should be avoided. When this requirement is met, large exposed wall surfaces and screen surfaces may be faced with less absorptive materials without serious consequence to privacy. The absorption provided by 25 mm rigid glass fibre or similar material is adequate for most situations.

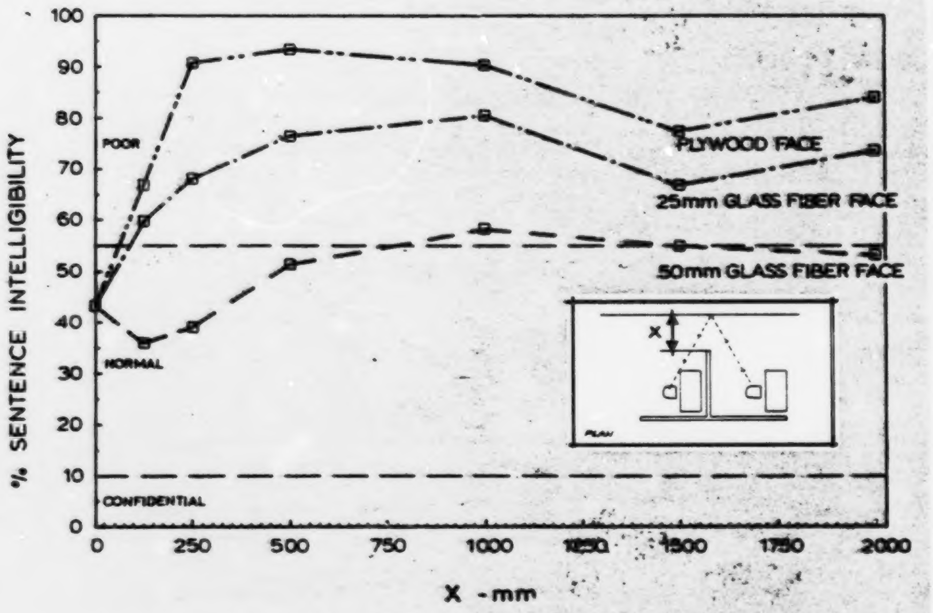
CEILING REQUIREMENTS

An ideal ceiling for use in an open plan office does not reflect any sound and is often referred to as "open sky". Some products perform very closely to this condition and should be specified whenever possible.

Conventional methods used to measure sound absorption characteristics are only indicative of a product's effectiveness in a diffuse sound field. This random incidence absorption is not necessarily applicable to the situation encountered in an open plan office. Speech sounds propagating between workstations reflect off the ceiling plane at specific angles depending on the separation between the talker and listener. At low incidence angles, some materials become relatively reflective, although they may exhibit very good random incidence absorption properties. Fortunately, most highly absorptive ceiling materials are not significantly affected in this manner. It is therefore usually acceptable to specify ceiling board absorption coefficients for each frequency band in the speech range. The primary drawbacks associated with this method of rating is the inability to quantify the effect of integral ceiling components that may be sound reflective.

If a ceiling is only intended to reduce noise created by general office activity, then the Noise Reduction Coefficient (NRC) can be used as the acoustical criterion. The NRC is a single number rating based on the random incidence absorption of a material averaged over the 250 Hz to 2000 Hz frequency bands. The NRC cannot be used for an open plan office criterion because it does not include the entire speech range and more importantly it does not weight the importance of the absorption relative to the frequency bands where speech intelligibility is most critical.

FIGURE 7



EFFECT OF VERTICAL REFLECTING SURFACES

A more recent descriptor, the Speech Privacy Noise Isolation Class (NIC′), overcomes many of the difficulties associated with the random incidence absorption. The NIC′ is a single number rating obtained under controlled open plan-like conditions with a test layout similar to that shown on Figure 3. Test results for a particular ceiling system including luminaires and support members, are indicative of what might be achieved in an open plan office where all other parameters have been optimized.

This descriptor, too, has limitations, primarily because it only considers the frequency range up to and including the 2000 Hz one-third octave band. The contribution to speech intelligibility above this frequency range can be very important and it is in these higher frequencies where the detrimental effect of specular reflections can be the greatest. Even so, the NIC′ is perhaps the best method for rating ceiling systems that is currently widely used by manufacturers.

Ceiling Absorption

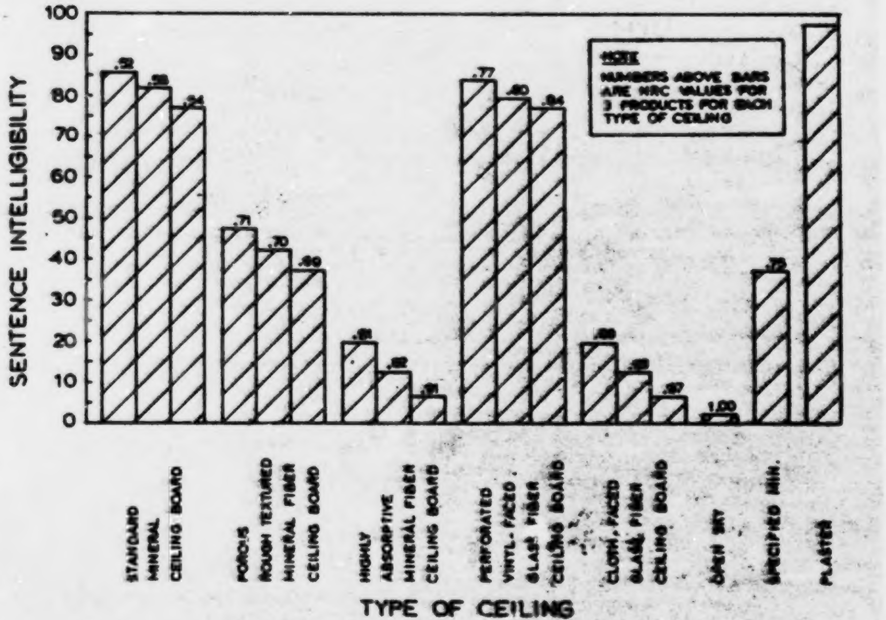
Using the prediction method outlined previously and assuming the standard workstation layout, a screen height of 1800 mm and an STC of 24, the effectiveness for a variety of ceiling boards is indicated on Figure 8. The large variation in the performance of the different types of boards clearly indicates the trends that can be expected under actual conditions.

Dense mineral boards, found in many non-open plan offices, have a minimal potential for providing privacy. Sentence Intelligibility values, even with tall screens, are in the marginal to negligible privacy range. The highly textured mineral boards are slightly more absorptive, but only an average level of privacy can be expected. Screen heights lower than assumed in this section would further reduce privacy to a point where it would be unacceptably low.

The vinyl faced glass fibre boards are particularly indicative of the inadequacy of the NRC as a criterion. Some of these products become very reflective in the higher speech frequency bands and drastically reduce privacy, although the NRC remains high.

The most suitable ceiling boards are made of either glass fiber material or mineral wool and have a porous facing. In general, the effectiveness of these boards increases with thickness. The products shown in Figure 8 with NRC values of 0.91 and 0.97 are 38 mm thick compared with the others in those groups that are only 25 mm. The subjective difference between any of these highly absorptive boards is slight although the thicker products should be

FIGURE 8



S.I. FOR VARIOUS CEILING BOARDS

considered if many of the workstations require confidential privacy. The open sky condition shows a small additional improvement in privacy and is very nearly representative of the performance of some 50 mm thick ceiling boards.

For new construction and renovations, the NIC′ should be used as a criterion for specifying a ceiling. For normal privacy conditions, a ceiling system with an NIC′ 18 or greater will be acceptable. In this range, it is not generally possible to obtain confidential privacy between adjacent workstations, but the level of distraction will be acceptable to most.

Offices where confidential privacy is the objective, require a ceiling system with an NIC′ at least of 21. This generally implies a thicker and more expensive product. A ceiling with this rating is only justified when many of the screens are at least 1800 mm high and have STC rating of 20 or more. In addition, the use of luminaires must be minimized or omitted and the layout must be optimized to provide maximum privacy.

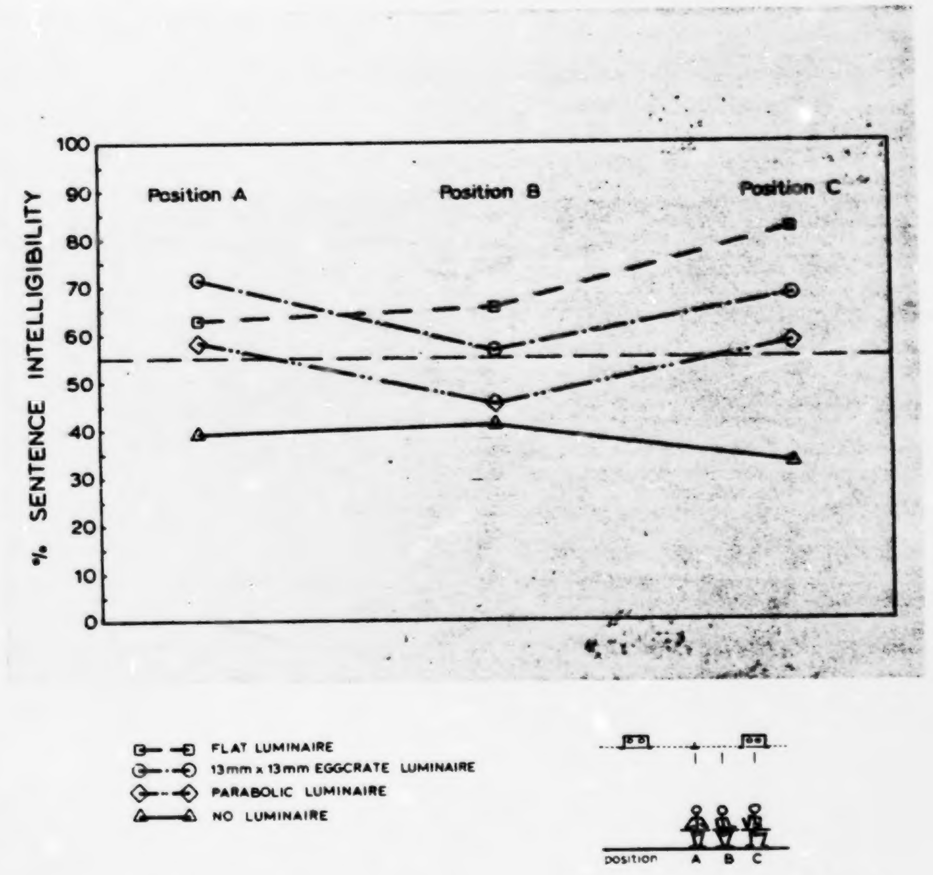
Ceiling materials in existing buildings may not have been rated in terms of the NIC′. When assessing such a ceiling, the minimum absorption coefficients for various frequency ranges as described below may be used as a criteria.

Frequency	Minimum Absorption Coefficient
250 Hz	0.50
500 Hz	0.60
1000 Hz	0.95
2000 Hz	0.95
4000 Hz	0.95

Luminaires

Adding luminaires can dramatically alter the performance of an absorptive ceiling. Test results for three types of luminaires are shown in Figure 9. The greatest effect, as expected, occurs when the screen is located directly under the light. At this position, all luminaires significantly reduced sound isolation. Flat lenses exhibit the poorest overall performance and could at some locations completely negate the benefit of a good ceiling. Parabolic luminaires had the least effect in general. Similar measurements, as described in Reference 2, indicate that deep egg-crate luminaires (75-100 mm) offer a useful improvement over the flat lens. Ideally, the use of indirect and task lighting is the preferred method of illuminating an open plan office from an acoustical point of view.

FIGURE 9



EFFECT OF DIFFERENT LUMINAIRES

Air Diffusers

Large diffusers located throughout the ceiling can reduce privacy by the same extent as luminaires. A preferable means of distributing air is to use slotted diffusers that are an integral part of the light fixture. With these diffusers, the exposed sound reflective surface area is usually no greater than the supporting T-bar. In offices where distributed overhead lighting is not used, the use of linear diffusers should be considered since they can be located near the perimeter of the office area and the workstation layout can easily accommodate their presence.

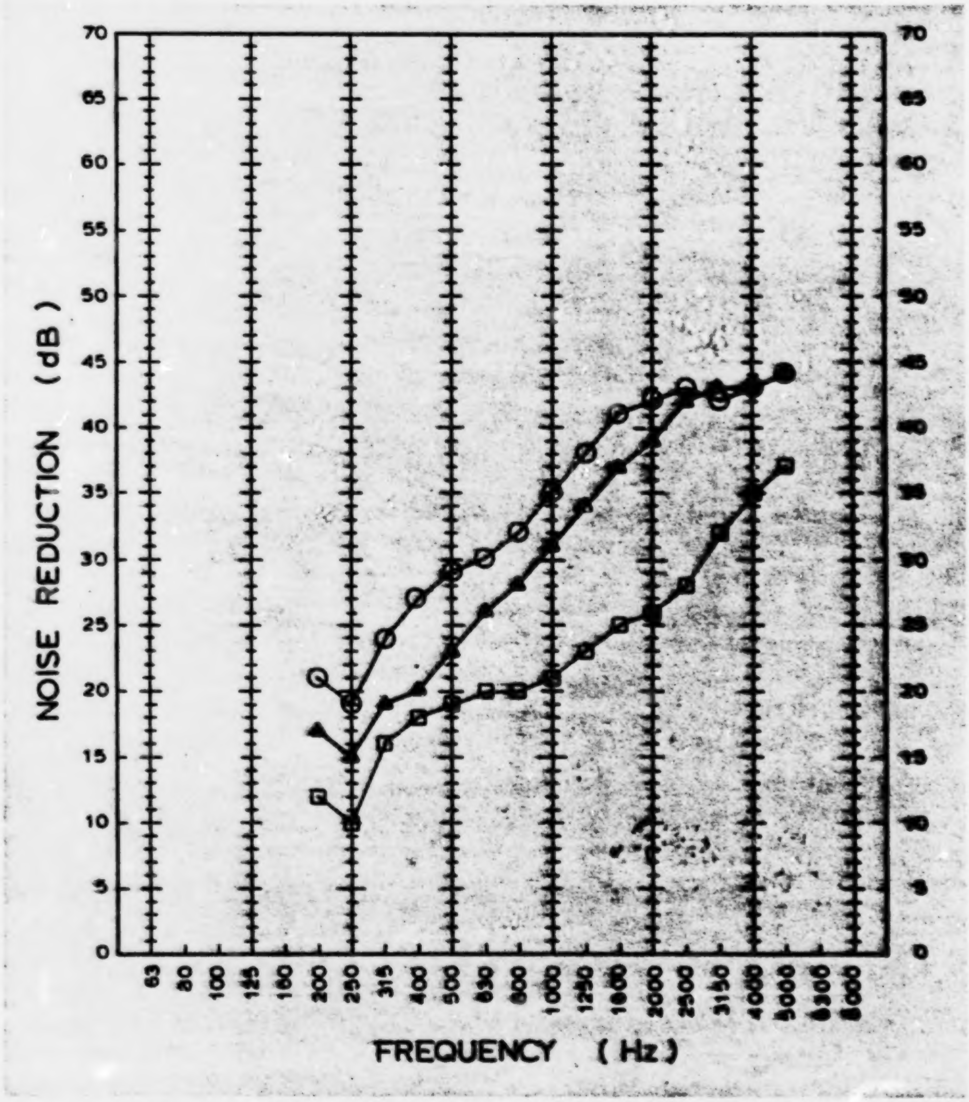
Ceiling Transmission Loss

Activities that occur in interview rooms, executive management offices, therapy rooms and so on, may require confidentiality at all times and perhaps at slightly elevated speech levels. The sound transmission loss of the ceiling board becomes critical under these circumstances since the dominant sound path between offices is through the suspended ceiling.

Figure 10 shows the noise reduction that can be expected between adjacent offices for three different ceiling products. All the boards meet the open plan absorption criteria and would therefore likely be used throughout the cellular space as well.

The measurements were taken in a typical office with a continuous suspended ceiling system. Several luminaires are located in each office and are fitted with return air slots that are open to a common plenum. The demising partition is of standard drywall and steel stud construction with an STC rating of 45.

FIGURE 10



□—□ 25 mm GLASS FIBER BOARD WITHOUT BACKING, STC 16
▲—▲ 25 mm GLASS FIBER BOARD WITH BACKING, STC 24
○—○ 22 mm MINERAL FIBER BOARD - STC 33

MEASURED NOISE REDUCTION BETWEEN OFFICES

The following table lists the A.I. values calculated for each ceiling condition. The masking level is assumed to be 43 dB(A).

A.I.			
Ceiling Board STC	Lowered Voice	Normal Voice	Raised Voice
16	0.06	0.18	0.34
24	0.02	0.06	0.13
33	0.00	0.03	0.07

Confidential privacy with the STC 16 ceiling is not likely to occur at normal or raised voice levels. The use of plenum barriers or slab to slab wall construction would be necessary to achieve privacy. The STC 24 product, however, will provide a near confidential level of privacy when a normal voice effort is used. Even at raised voice levels, privacy can be considered to be normal. The more dense, STC 33 board, provides additional noise reduction resulting in very good privacy even at elevated speech levels.

Ceilings with high STC ratings are also more effective in reducing noise from mechanical equipment located in the plenum. This is an important consideration where the use of a masking system is proposed since there should be very little noise created by other building systems.

Offices that rely on masking noise generated only by the activity of the occupants, will need a ceiling with a yet much higher STC. If the office is very active and the mechanical system is audible, an STC of approximately 33 is usually adequate for average privacy and 40 or greater is necessary for confidential privacy. In very quiet offices, a continuous suspended ceiling with return air slots to an open plenum will not provide confidential privacy, even at normal voice levels. Full height construction should be used in these cases.

LAYOUT REQUIREMENTS

Due to the directionality of the human voice, speaker to listener orientation greatly affects privacy. Speech levels heard by a listener are greatest when the talker is directly facing the listener. Arranging desks and other furnishings appropriately helps to optimize privacy for some of the time. Unfortunately, the privacy conditions change throughout the day as people move about, raise or lower their voices, stand up or sit down, and so on. The design can only accommodate the predictable seating arrangements at best. A general list of do's and don'ts is provided in the Acoustic Performance Requirements Section.

REFERENCES

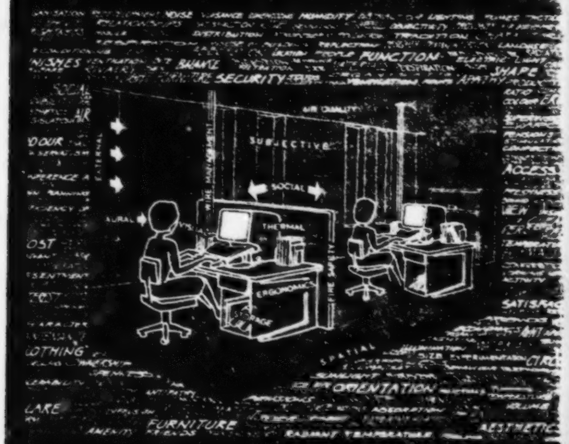
1) American National Standard Methods for the Calculation of the Articulation Index. ANSI 53.5-1969.

2) Warnock A.C.C. (1978) Studies of Acoustical Parameters in Open Plan Offices. JASA 63 (3) March.

3) Warnock A.C.C. (1973) Acoustical Investigation of Ceiling Performance in an Open Plan Office. Building Research Note No. 88, DBR, NRC.

4) Moquin P., Kruger K. (1984) Computer Prediction of Speech Privacy In Open Plan Offices. Paper Presented at 1984 Canadian Acoustical Association Symposium, Quebec.

ELECTRONIC OFFICE DESIGN GUIDE


NOISE
HUMIDITY
LIGHTING
RELATIONSHIPS
DISTRIBUTION
TRADITION
FUNCTION
NISHES
SHAPE
SECURITY
APATHY
SOCIAL
AIR
ODOUR
EXTERNAL
AIR QUALITY
SUBJECTIVE
WIRE MANAGEMENT
SOCIAL
ACCESS
AURAL
VISUAL
THERMAL
OST
FIRE SAFETY
ERGONOMICS
STORAGE
SATISFAC
OTHING
SPATIAL
SIZE
ORIENTATION
LARE
FURNITURE
AMENITY
RADIANT TEMPERATURE
AESTHETIC

THERMAL COMFORT

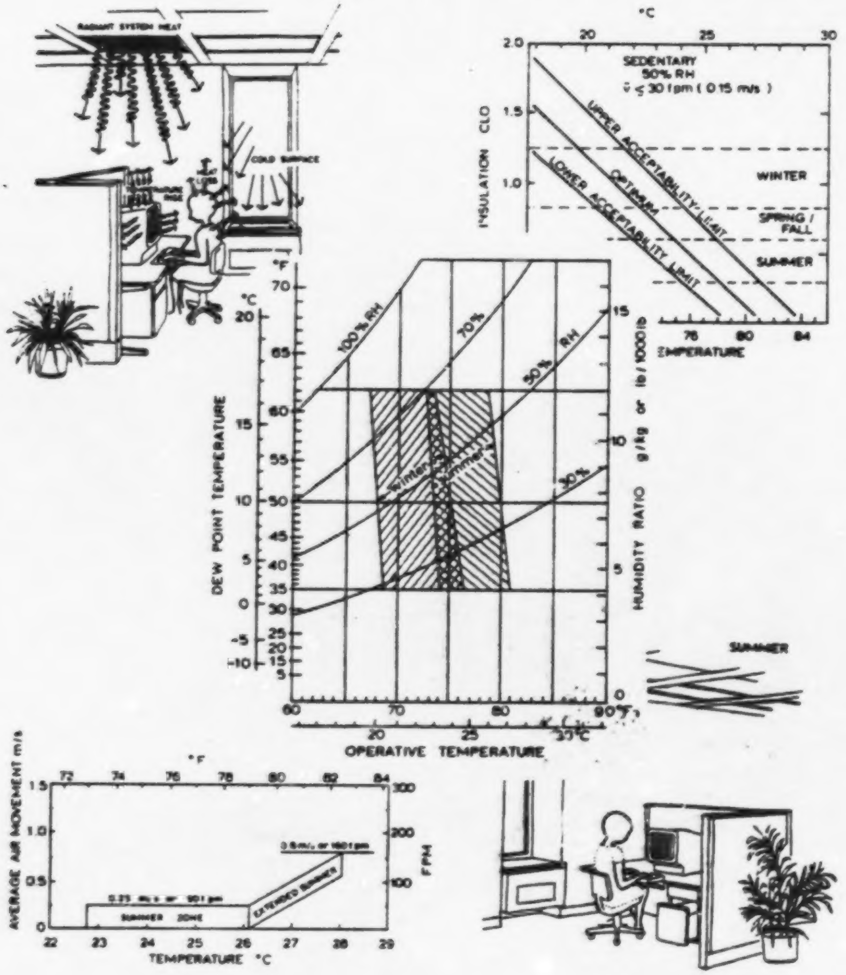
INTRODUCTION

The purpose of this section of the design guide is to specify the combination of factors necessary for thermal comfort in the electronic office environment. The important environmental parameters are temperature, radiation, humidity and air movement while the important personal parameters are clothing and activity.

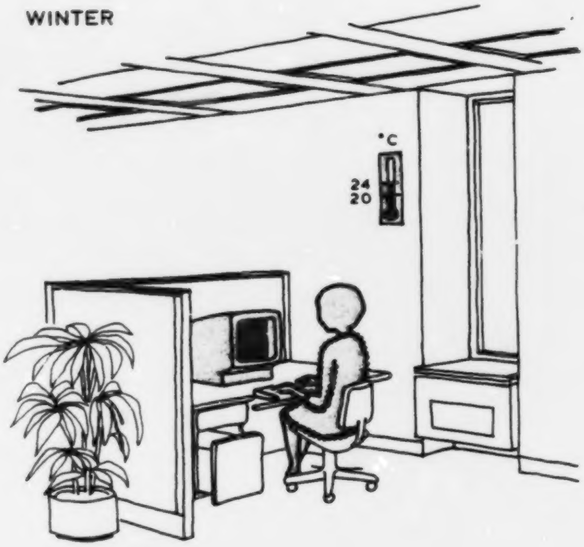
Satisfaction with the thermal environment is a complex response to these interacting parameters as well as to such seemingly extraneous factors as energy supply, fashions etc... Despite the complexity, the specification for a comfortable working environment must be made, where possible, in quantitative terms. Over the years, many comfort indices have been proposed; most of them inadequate as predictors of thermal comfort. Two comprehensive and highly satisfactory ways of treating the responses of human beings to the thermal environment are readily available and form the basis for the guidelines proposed here:

i. Fanger's Comfort Equation is concerned primarily with the definition and identification of comfort conditions; its only drawback being its complexity.

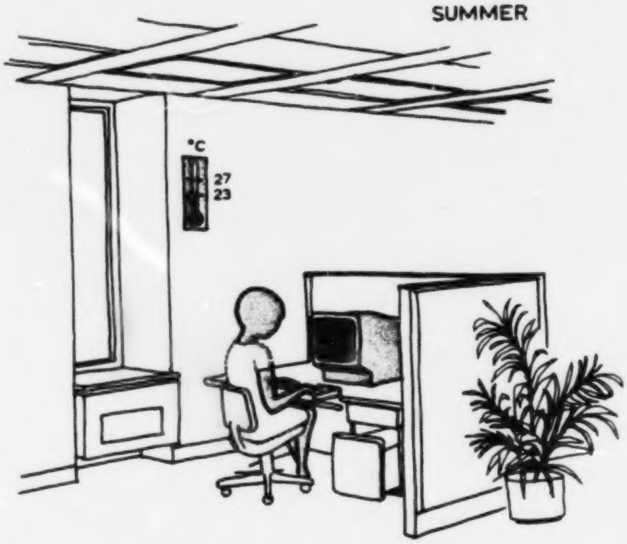
ii. ASHRAE deals in practical terms with a wide range of situations specifying, in consensus standards, conditions in which 80% or more of the occupants will find the environment thermally acceptable. The ANSI/ASHRAE Standard 55-81 which forms the basis of these guidelines has undergone public review and professional scrutiny and incorporates appropriate research and experience gained over the years. *(Excerpts from the Standard are printed here by permission of the American Society of Heating, Refrigerating and Air-Conditioning Engineers, Inc., 1791 Tullie Circle, N.E., Altanta, GA. 30329).*


RADIANT SYSTEM HEAT
COLD SURFACE
°C
20
25
30
2.0
1.5
1.0
INSULATION CLO
SEDENTARY
50% RH
v̄ ≤ 30 fpm (0.15 m/s)
UPPER ACCEPTABILITY LIMIT
OPTIMUM
LOWER ACCEPTABILITY LIMIT
WINTER
SPRING / FALL
SUMMER
76
80
84
TEMPERATURE
°F
°C
DEW POINT TEMPERATURE
100% RH
70%
50% RH
30%
Winter
Summer
HUMIDITY RATIO g/kg or lb/1000 lb
60
70
80
90°F
20
25
30°C
OPERATIVE TEMPERATURE
SUMMER
°F
72
74
76
78
80
82
84
AVERAGE AIR MOVEMENT m/s
1.5
1.0
0.5
0
300
200
100
FPM
0.8 m/s or 160 fpm
0.25 m/s or 50 fpm
SUMMER ZONE
EXTENDED SUMMER
22
23
24
25
26
27
28
29
TEMPERATURE °C

Design guides often give the impression of defining an ideal environment. In electronic offices, as in offices generally, (or in more generic terms in spaces which accommodate sedentary people in typical indoor clothing), the various environmental parameters would vary from point to point and also in time. This is not necessarily a bad thing - steady state conditions tend to be not stimulating; but there is a point where stimulation becomes discomfort. This point varies from person to person and from time to time. The design conditions, therefore, define only a target environment or, more precisely, an environmental range - the fluctuations within the range being such that discomfort is not caused to a significant proportion of the occupants. The design guide will include consideration of winter and summer comfort temperature ranges based on seasonal clothing habits; limits on the thermal nonuniformities in the space such as draft, temperature variation and radiant asymmetry which can cause local discomfort, temperature adjustments for activity and allowance in summer of higher temperatures if air movement is correspondingly increased.


WINTER
°C
24
20

TYPICAL WINTER CLOTHING (0.9 Clo.)

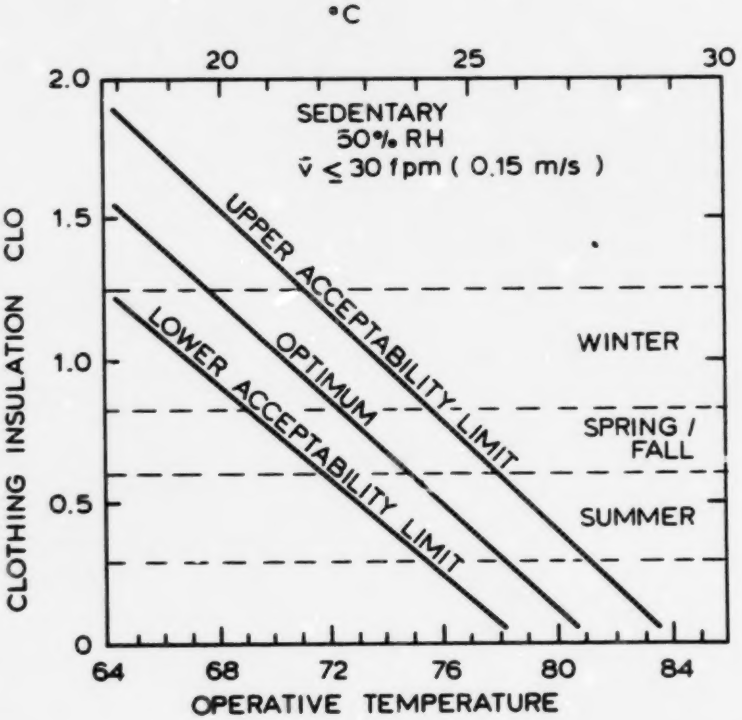

SUMMER
°C
27
23

TYPICAL SUMMER CLOTHING (0.5 Clo.)

TEMPERATURE REQUIREMENTS

1.0 The operative temperature range shall be satisfactory to at least 80% of occupants (sedentary and near sedentary) based on the typical winter clothing (0.9 clo) and typical summer clothing (0.5 clo).

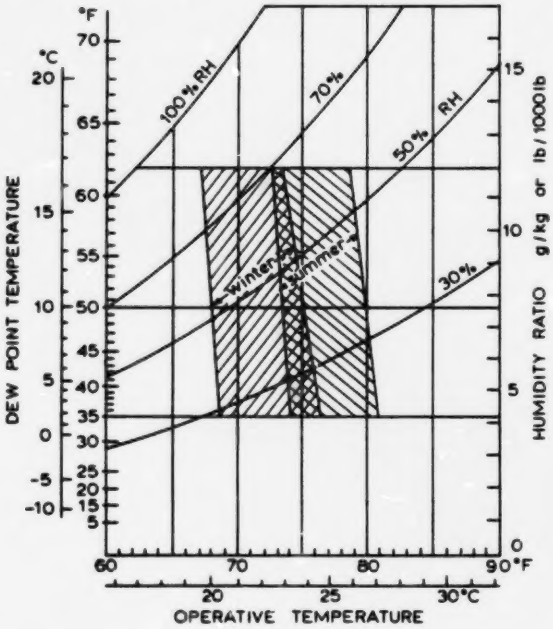
(1 clo = 0.155 m^2K/w; a numerical representation of a clothing ensemble's thermal resistance)



CLOTHING INSULATION FOR VARIOUS LEVELS OF COMFORT AT A GIVEN TEMPERATURE (ACTIVITY LEVEL: 1.2 MET)

(ANSI/ASHRAE 55-1981)

2.0 The environment shall maintain operative temperature and humidities, for winter and summer, within the acceptable range shown on the psychrometric chart.



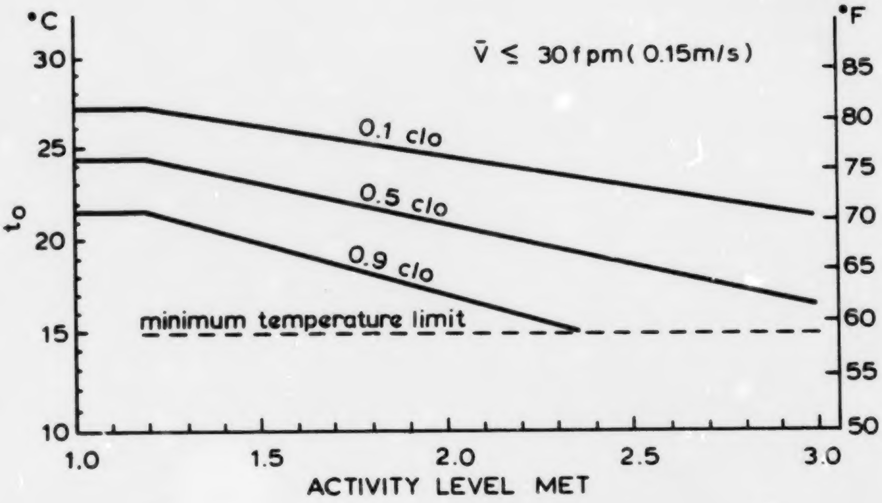
ACCEPTABLE RANGES OF TEMPERATURE AND HUMIDITY FOR PERSONS IN TYPICAL SUMMER AND WINTER CLOTHING (ACTIVITY LEVEL 1.2 MET)

(ANSI/ASHRAE 55-1981)

3.0 Sedentary Non-typical Clothing: Comfort conditions for clothing levels different from those of Clause 1.0 can be determined approximately by lowering the temperature ranges by 0.6°K for each 0.1 clo of increased clothing. For sedentary occupancy of more than an hour, the minimum operative temperature shall not be less than 18°C.

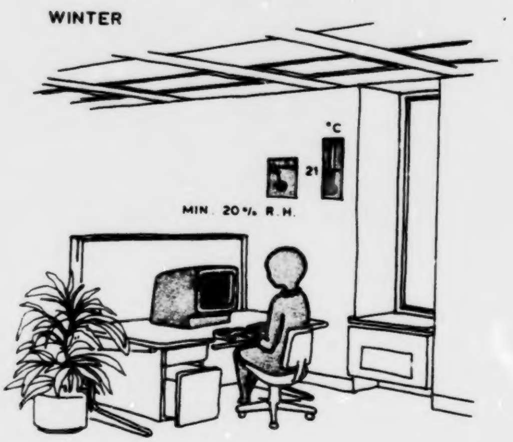
(ANSI/ASHRAE 55-1981)

4.0 Active Persons: The comfort zone temperatures stated in Clause 1.0 shall be decreased when the average steady state activity level of occupants is higher than sedentary or slightly active (1.2 met). The acceptable operative temperature for activity depends on both the time-averaged activity level and the clothing insulation. Acceptable adjusted operative temperature is given in the graph.

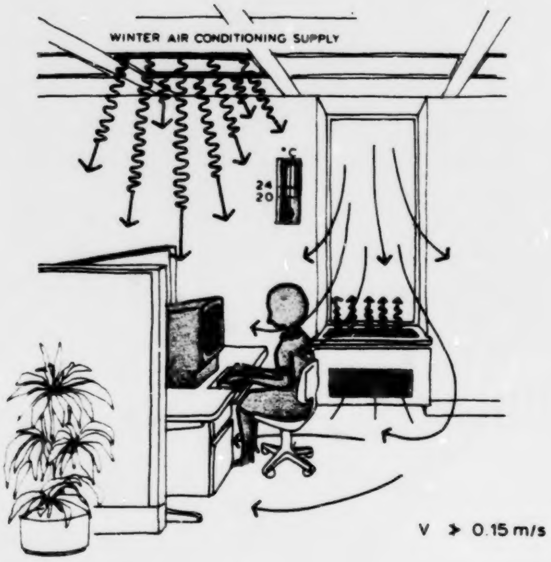


OPTIMUM TEMPERATURES FOR ACTIVE PEOPLE IN LOW AIR MOVEMENT (v ≤ 15 m/s (30fpm) ENVIRONMENTS

(ANSI/ASHRAE 55-1981)


WINTER
°C
21
MIN. 20 % R.H.

RELATIVE HUMIDITY


WINTER AIR CONDITIONING SUPPLY
°C
24
20
V > 0.15 m/s

PREVENT LOCAL DRAFT DISCOMFORT

HUMIDITY REQUIREMENTS

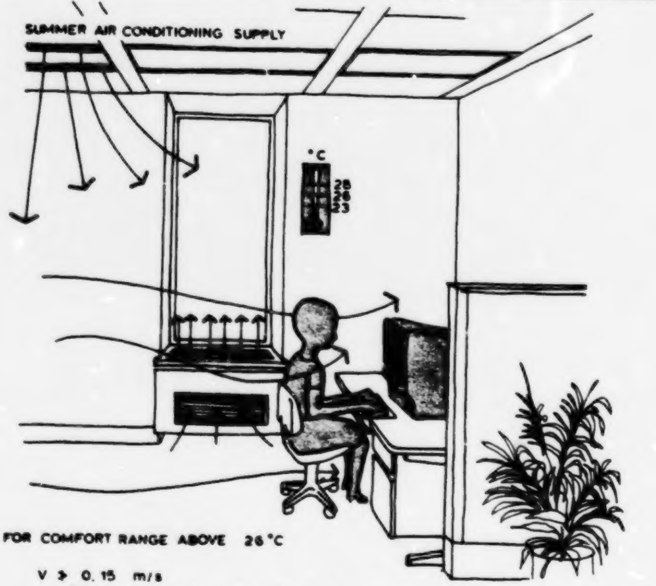
5.0 For electronic offices in winter, the limits of humidity will be determined on the basis of a compromise between static electricity generation which requires that the humidity be as high as possible while the condensation and subsequent ice lensing within the building fabric dictates that the humidity be as low as possible. A relative humidity of 20% at 21°C is deemed to be a reasonable compromise at an outdoor temperature of -30°C.

(ANSI/ASHRAE 55-1981)

AIR MOVEMENT

6.1 **Winter:** The average air movement in offices shall not exceed 0.15 m/s (30fpm). If the temperature is less than the optimum or neutral sensation temperature, the maintenance of low air movement is important to prevent local draft discomfort.

(ANSI/ASHRAE 55-1981)


SUMMER AIR CONDITIONING SUPPLY
°C
28
26
23

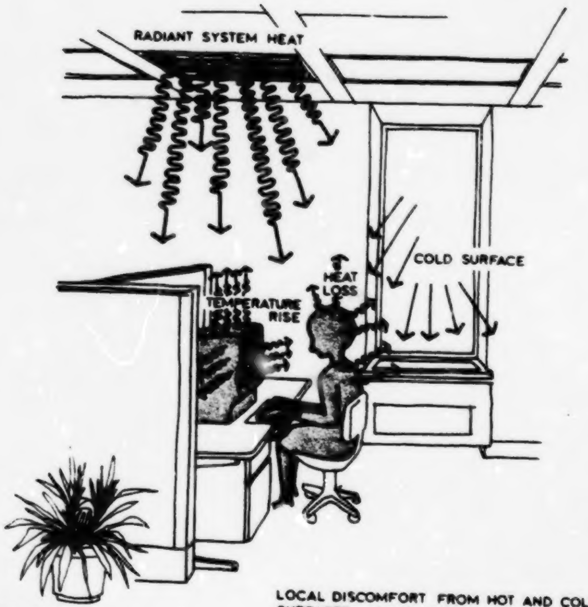
FOR COMFORT RANGE ABOVE 26 °C

$V > 0.15$ m/s

$V = [0.25 + 0.275 (T - 26)]$ m/s

$V > 0.8$ m/s

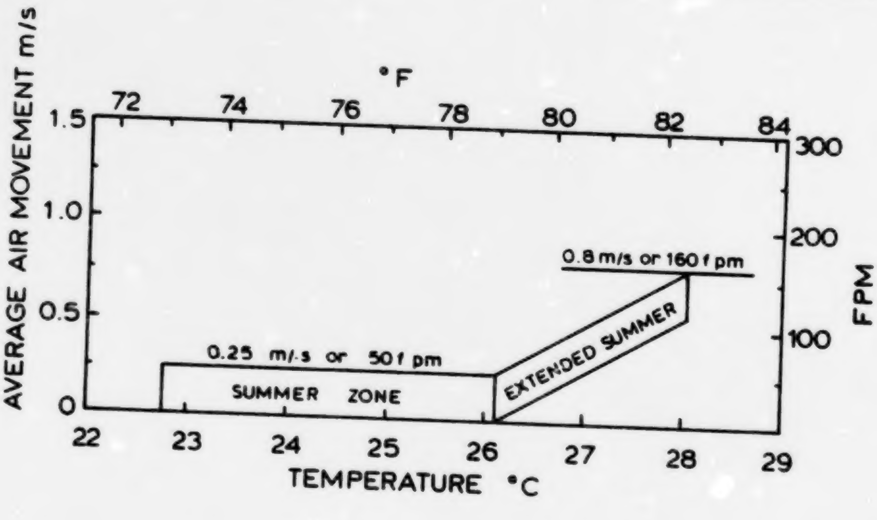
LIMITS ON AIR MOVEMENT TO MAINTAIN COMFORT


RADIANT SYSTEM HEAT
TEMPERATURE RISE
HEAT LOSS
COLD SURFACE

MINIMIZE LOCAL DISCOMFORT

LOCAL DISCOMFORT FROM HOT AND COLD SURFACES (ALSO DIRECT SUNLIGHT) REDUCING THERMAL ACCEPTABILITY

6.2 **Summer:** The average air movement in the office shall not exceed 0.25 m/s (50fpm). However, the comfort zone can be extended above 26°C if the average air movement is increased 0.275 m/s (55fpm) for 1°K of increased temperature to a maximum of 28°C and air movement 0.8 m/s (160fpm). (Loose paper, hair and other light objects may then start to be blown about.)



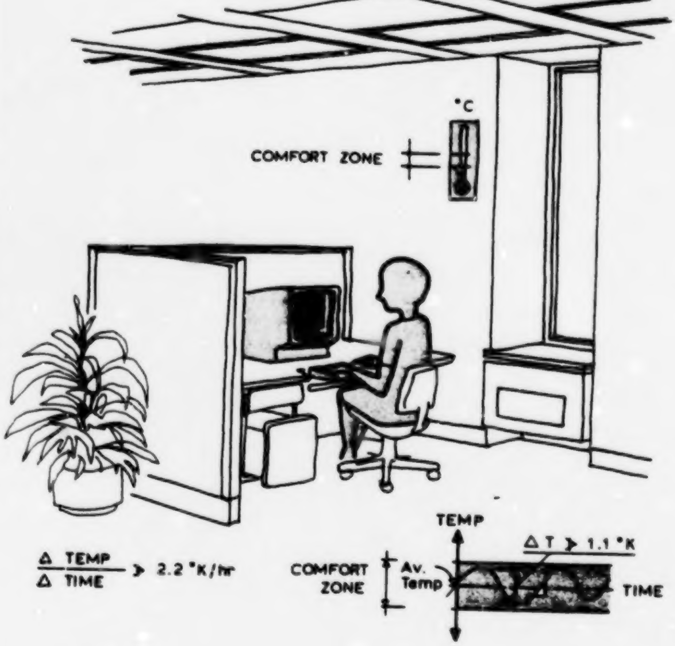
RANGE OF AVERAGE AIR MOVEMENTS FOR SUMMER AND EXTENDED SUMMER ZONES

(ANSI/ASHRAE 55-1981)

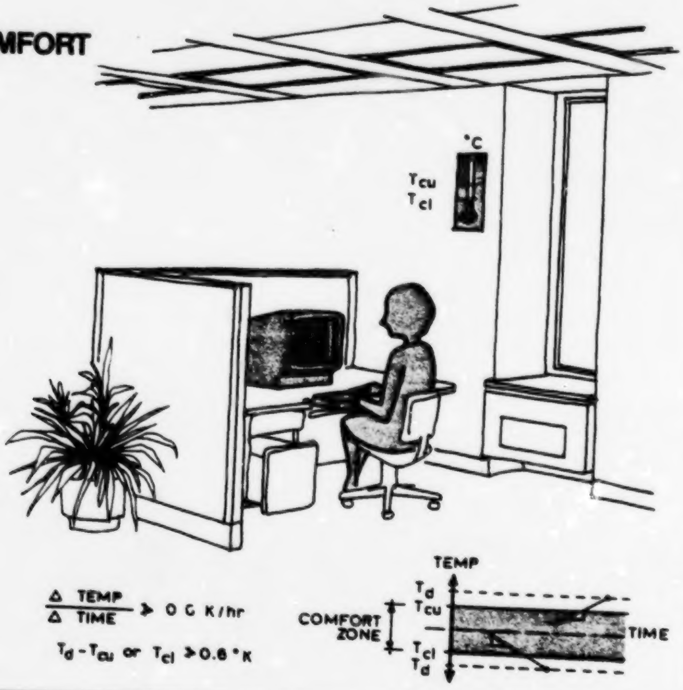
MEAN RADIANT TEMPERATURE

7.0 For offices where air movement is low, the operative temperature is approximately the average of air temperature and mean radiant temperature. In electronic offices, where the heat gains of equipment is likely to cause an increase in the mean radiant temperature locally, appropriate measures should be taken to keep the operative temperature within the appropriate comfort zone; (the measures may involve adjustments of air temperature or the mean temperature).

(ANSI/ASRAE 55-1981)


°C
COMFORT ZONE
TEMP
Δ TEMP / Δ TIME > 2.2 °K/hr
COMFORT ZONE
Av. Temp
ΔT > 1.1 °K
TIME

MINIMIZE DISCOMFORT


°C
T_{cu}
T_{cl}
TEMP
Δ TEMP / Δ TIME > 0 6 K/hr
$T_d - T_{cu}$ or T_{cl} > 0.8 °K
T_d
T_{cu}
COMFORT ZONE
TIME
T_{cl}
T_d

TEMPERATURE CYCLING

8.0 If the peak variation in operative temperature exceeds 1.1°K, the rate of change of temperature shall not exceed 2.2° K/h. (There are no restrictions on the rate of temperature change if the peak to peak is 1.1°K or less).

(ANSI/ASHRAE 55-1981)

TEMPERATURE DRIFTS OR RAMP

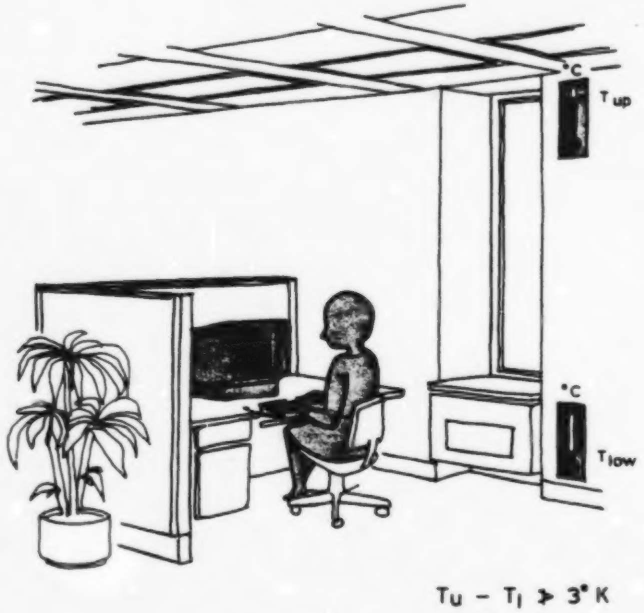
9.0 Temperature drifts or ramps are monotonic, steady, non-cyclical temperature changes (Drifts refer to passive temperature changes and ramps to actively controlled temperature changes). Slow rates of operative temperature change (approximately 0.6°K/h during the occupied period are acceptable provided the temperature during a drift or ramp does not extend beyond the comfort zone by more than the 0.6°K and for longer than one hour.

(ANSI/ASHRAE 55-1981)

VERTICAL TEMPERATURE DIFFERENCES

10.0 To prevent local discomfort the vertical air temperature difference within the occupied zone, measured at the 0.1 m and 1.7 m levels shall not exceed 3°K.

(ANSI/ASHRAE 55-1981)



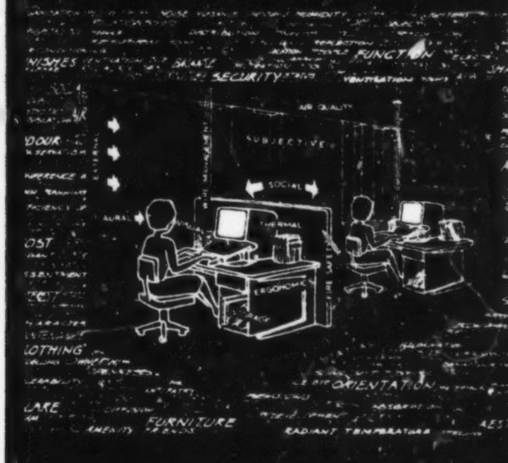
MINIMIZE LOCAL DISCOMFORT
(COLD AT FEET, WARM AT HEAD)

REFERENCES

1. Fanger, P.O. "Thermal Comfort". McGraw Hill, 1972.

2. ANSI/ASHRAE 55-1981 "Thermal Environmental Conditions for Human Occupancy". American Society of Heating Refrigerating and Air Conditioning Engineering.

ELECTRONIC OFFICE DESIGN GUIDE


FUNCTION
SECURITY
VENTILATION
AIR QUALITY
SUBJECTIVE
EXTERNAL
SOCIAL
AURAL
THERMAL
ERGONOMICS
ORIENTATION
FURNITURE
AMENITY
RADIANT TEMPERATURE

INDOOR AIR QUALITY

INTRODUCTION

The purpose of this section of the design guide is to specify indoor air quality and minimum ventilation rates in the electronic office environment which will be acceptable to human occupants and will not impair health. Indoor air should not contain contaminants that exceed concentrations known to impair health or cause discomfort to occupants. Such contaminants include various gases, vapors, micro-organisms, smoke and other particulate matter. These may be present in make-up air (outdoor air introduced into the building) or be introduced from indoor activities, furnishings, building materials, surface coatings, air handling and air treatment components. Factors that may harm or destroy health include infection or allergies, irritants, extreme thermal conditions and objectionable odors. Acceptable indoor air quality can be achieved by one of two alternate procedures namely the "Ventilation Rate Procedure" or the "Indoor Air Quality Procedure". ASHRAE Standard 62-1981, which forms the basis of these guidelines, applies to all indoor or enclosed spaces which people may occupy. This standard reflects experience gained over the years with appropriate professional scrutiny and public review and thus would be appropriate for electronic office spaces. *(Excerpts from the standard are printed here by permission of the American Society of Heating Refrigerating and Air-Conditioning Engineers Inc., 1791 Tulie Circle, N.E. Atlanta GA. 30329).*

VENTILATION RATE PROCEDURE

1.0 ACCEPTABLE OUTDOOR AIR

1.1 Contaminants in outdoor air shall not exceed allowable limits listed in Table 1.

(ENVIRONMENTAL MEASUREMENT)

TABLE 1
AMBIENT AIR QUALITY STANDARDS*

Contaminant	Long Term		Short Term	
	Level	Time	Level	Time
Carbon Monoxide			40mg/m^3	1Hr.
			100mg/m^3	8Hrs.
Lead	1.5μg/m^3	3Mo		
Nitrogen Dioxide	100μg/m^3	Yr.		
Oxidants (Ozone)			235μg/m^3	1Hr.
Particulates	75μg/m^3	Yr.	260μg/m^3	24Hrs.
Sulfur Dioxide	80μg/m^3	Yr.	365μg/m^3	24Hrs.

* Pertinent local regulations should also be checked. Some regulations may be more restrictive than those given here, and additional substances may be regulated.

1.2 Outdoor air shall be considered unacceptable if it is known to contain any contaminant at a concentration exceeding those listed in Table 2.

(ENVIRONMENTAL MEASUREMENT)

TABLE 2
ADDITIONAL AMBIENT AIR QUALITY GUIDELINES

Contaminant	Long Term		Short Term	
	Level*	Time	Level	Time
Acetone-O**	7mg/m^3	24Hrs.	24mg/m^3	30min.
Acrolein-O			25μg/m^3	C***
Ammonia-O	0.5mg/m^3	Yr.	7mg/m^3	C
Beryllium	0.01μg/m^3	30Days		
Cadmium	2.0μg/m^3	24Hrs.		
Calcium Oxide (Lime)			20-30μg/m^3	C
Carbon Disulfide-O	0.15mg/m^3	24Hrs.	0.45mg/m^3	30min.
Chlorine-O	0.1mg/m^3	24Hrs.	0.3mg/m^3	30min.
Chromium	1.5μg/m^3	24Hrs.		
Cresol-O	0.1mg/m^3	24Hrs.		
Dichloroethane-O	2.0mg/m^3	24Hrs.	6.0mg/m^3	30min.
Ethyl Acelate-O	14mg/m^3	24Hrs.	42mg/m^3	30min.
Formaldehyde-O			120μg/m^3	C
Hydrochloric Acid-O	0.4mg/m^3	24Hrs.	3mg/m^3	30min.
Hydrogen Sulfide-O	40-50μg/m^3	24Hrs.	42μg/m^3	1Hr.
Mercaptans-O			20μg/m^3	1Hr.
Mercury	2μg/m^3	24Hrs.		
Methyl Alcohol-O	1.5mg/m^3	24Hrs.	4.5mg/m^3	30min.
Methylene	20mg/m^3	Yr.	150mg/m^3	30min.
Chloride-O	50mg/m^3	24Hrs.		
Nickel	2μg/m^3	24Hrs.		
Nitrogen Monoxide	0.5mg/m^3	24Hrs.	1mg/m^3	30min.
Phenol-O	0.1mg/m^3	24Hrs.		
Sulfates	4μg/m^3	Yr.		
	12μg/m^3	24Hrs.		
Sulfuric Acid-O	50μg/m^3	Yr.	200μg/m^3	30min.
	100μg/m^3	24Hrs.		
Trichlorethylene-O	2mg/m^3	Yr.	16mg/m^3	30min.
	5mg/m^3	24Hrs.		
Vanadium	2μg/m^3	24Hrs.		
Zinc	50μg/m^3	Yr.		
	100μg/m^3	24Hrs.		

* Unless otherwise specified all air quality measurements should be corrected to standard conditions of 25°C(77F) temperature and 760 mm. (29.92 inches) of mercury pressure. (101.3kPa).

** These materials marked "O" have odors at concentrations sometimes found in outdoor air. The tabulated concentration levels do not necessarily result in odorless conditions.

*** Ceiling or maximum allowable concentrations.

1.3 If the air is thought to contain any contaminant not listed in Clauses 1.1 or 1.2, guidance on acceptable exposure levels should be obtained by reference to the Occupational Health and Safety Standards.

(AIR SAMPLING AND ANALYSIS)

1.4 If after complying with Clauses 1.1, 1.2 and 1.3, there is still a reasonable expectation that the air is unacceptable, sampling shall be conducted in accordance with the local authorities having jurisdiction.

(AIR SAMPLING AND ANALYSIS)

2.0 OUTDOOR AIR TREATMENT

2.1 If the outdoor air contaminant levels exceed the values given in Clauses 1.1 and 1.2, the air shall be treated to control the offending contaminants.

(PRODUCT SPECIFICATIONS)

3.0 VENTILATION REQUIREMENTS

3.1 Indoor air quality shall be considered acceptable if the required rates of acceptable outdoor air specified in the Table are provided for the occupied space and no unusual indoor air contaminants are present.

OUTDOOR AIR REQUIREMENTS (per person)

	Est. Occupancy*	Smoking	Non Smoking
Office space	(7)	10.0 L/s(20cfm)	2.5 L/s(5cfm)
Meeting & waiting	(60)	17.5 L/s(35cfm)	3.5 L/s(7cfm)

* Based on estimated occupancy persons per $100m^2$ floor area.

(AIR FLOW RATE MEASUREMENT)

3.2 When smoking is allowed in occupied spaces, the amount of outdoor air required shall be determined by the "smoking" Guideline in Clause 3.1. However, any areas within those spaces which are designated "non-smoking" may have their outdoor air determined from the "non-smoking" Guideline in Clause 3.1 provided that air is not recirculated from, or otherwise enters from, the smoking areas.

(SITE INSPECTION)

3.3 Outdoor air shall be supplied to the indoor space to dilute CO_2 produced by metabolism and expired from the occupants' lungs. This supply shall minimally be 2.5 L/S per person which allows for an adequate factor of safety to account for health variations and some increased activity levels.

(AIR FLOW RATE MEASUREMENT)

3.4 Exhaust air from one space sometimes can be used as supply air to another space where different contaminants are generated (e.g. corridors and office spaces exhausted through toilets); this exhaust air shall then be considered equivalent to acceptable outdoor air.

(VISUAL INSPECTION)

3.5 When spaces are unoccupied, ventilation is not generally required. Ventilation may be required, however, to prevent accumulation of contaminants injurious to people, contents or structure.

(AIR SAMPLING AND ANALYSIS)

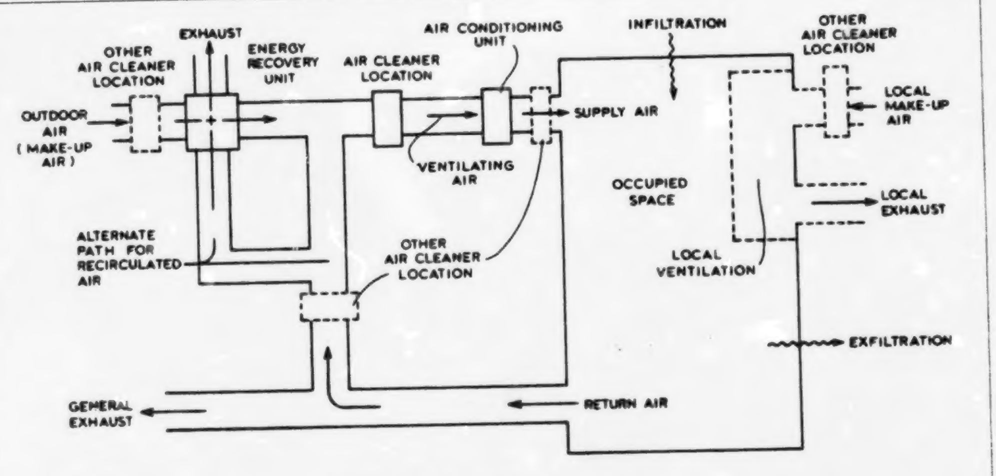
4.0 RECIRCULATION CRITERIA

4.1 The requirements for ventilation air qualities specified in Clause 3.1 are for 100% outdoor air when the outdoor air meets the specifications for air quality given in Clauses 1.1 and 1.2. While these quantities are for 100% outdoor air, they also set the amount of air required to dilute contaminants to acceptable levels. If proper air cleaners and adequate temperature control are provided, part of this air may be recirculated, but the outdoor air portion must never be less than the rates indicated in Table 3.

(AIR FLOW RATE MEASUREMENT)

4.2 The air cleaning system for the recirculated air may be located in the recirculated air stream or in the plenum which mixes the outdoor air and return air.

(MECHANICAL DRAWINGS REVIEW)


EXHAUST
OTHER AIR CLEANER LOCATION
ENERGY RECOVERY UNIT
AIR CLEANER LOCATION
AIR CONDITIONING UNIT
INFILTRATION
OTHER AIR CLEANER LOCATION
OUTDOOR AIR (MAKE-UP AIR)
SUPPLY AIR
LOCAL MAKE-UP AIR
VENTILATING AIR
OCCUPIED SPACE
LOCAL EXHAUST
ALTERNATE PATH FOR RECIRCULATED AIR
OTHER AIR CLEANER LOCATION
LOCAL VENTILATION
EXFILTRATION
GENERAL EXHAUST
RETURN AIR

VENTILATION SYSTEM

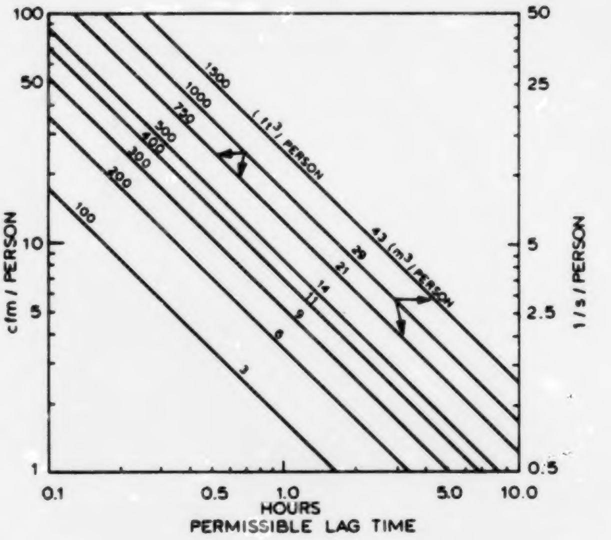
4.3 The air cleaning system used to reclaim recirculated air shall be designed to remove particulate and gaseous contaminants. The required air cleaner efficiency (ASHRAE 62-1981) and recirculation rate for the system shall be sufficient to provide an indoor air quality equivalent to that obtained using outdoor air as specified in Clauses 1.1 and 1.2 and at a rate specified in Clause 3.1.

(AIR SAMPLING AND ANALYSIS/AIR FLOW RATE MEASUREMENT/
BY CALCULATION)

5.0 VARIABLE OCCUPANCY

5.1 When contaminants are associated only with occupants and are dissipated by natural means during unoccupied periods, supply of outdoor air may lag occupancy. When contaminants are generated in the space, independent of occupants or their activities, supply of outdoor air should lead occupancy so that acceptable conditions will exist at the start of occupancy. Figure 1 and 2 provide guidelines for lag or lead times needed to achieve acceptable conditions for transient occupancy.

(MECHANICAL SYSTEM OPERATING PROCEDURE)



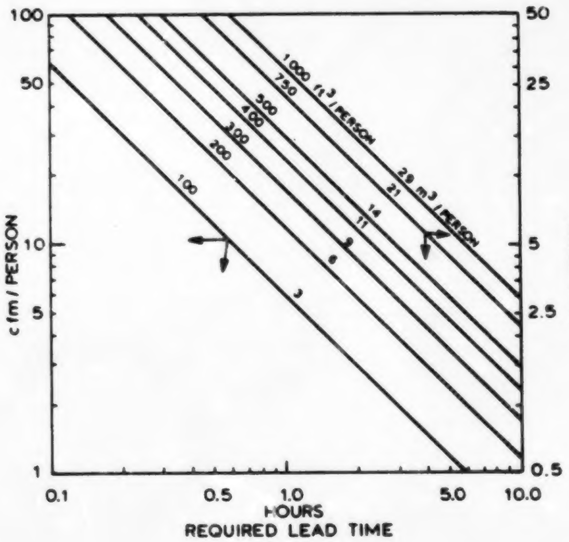
MAXIMUM PERMISSIBLE VENTILATION LAG TIME

5.2 Ventilating systems, for spaces with transient or variable occupancy, may have their outdoor air quality adjusted by use of dampers, by stopping and starting the system, or by other means, to provide sufficient dilution of contaminant concentrations within acceptable levels at all times. Such system adjustment may lag or lead occupancy depending on the source of contaminants and the variation in occupancy.

(MECHANICAL SYSTEM OPERATING PROCEDURE)

5.3 Ventilating systems may be adjusted to compensate for variable occupancy when contaminants are associated only with the occupants.

(MECHANICAL SYSTEM OPERATING PROCEDURE)



MINIMUM VENTILATION TIME REQUIRED
BEFORE OCCUPANCY OF SPACE

TABLE 4
SELECTED GUIDELINES FOR AIR CONTAMINANTS OF INDOORS ORIGIN

Contaminants	Concentration**	Exposure Time	Comments
Acetone-O*			
Ammonia-O			
Asbestos	—	—	Known human carinogen, best available control technology.
Benzene-O	—	—	Known human carinogen, best available control technology
Carbon Dioxide	4.5$\mu g/m^3$	Continous	—
Chlordane-O	5$\mu g/m^3$	Continous	—
Chlorine	—	—	—
Cresol-O	—	—	—
Dichloromethane-O	—	—	—
Formaldehyde-O	120$\mu g/m^3$	Continous	W. German and Dutch Guidelines
Hydrocarbons, Aliphatic-O		—	—
Hydrocarbons, Aromatic-O		—	—
Mercury	—	—	—
Ozone-O	100$\mu g/m^3$	Continuous	—
Phenol-O	—	—	—
Radon	0.01 Working Level(WL)	Annual average	—
Tetrachloroethylene-O	—	—	—
Trechloroethane-O	—	—	—
Turpentine-O	—	—	—
Vinyl Chloride-O	—	—	Known human carinogen, best available control technology.

* These material marked "O" have odors at conentration sometimes found in indoor air. The tabulated concentration do not necessarily result in odorless conditons.

** These substances are ones for which indoor exposure are not yet available.

INDOOR AIR QUALITY PROCEDURE

1.0 ACCEPTABLE INDOOR AIR

1.1 In recent years problems have arisen from contaminants unrelated to occupancy, but rather generated from the building itself and its contents, such as asbestos dust, radon gas and vapours of formaldehyde and mercury. Such contaminants shall be controlled where a regulation of notable indoor contaminants has been developed (Table 4). Other contaminants undoubtedly will be identified and require attention beyond this listing.

(AIR SAMPLING AND ANALYSIS)

1.2 Various indoor activities may give rise to odor of unacceptable intensity or character, or to airborne materials that irritate the eyes, nose, or throat. In an absence of objective means to assess the acceptability of such contaminants, the judgement of acceptability must necessarily be derived from subjective evaluations of impartial observers. The air can be considered acceptably free of annoying contaminants if 80% of a panel of at least 20 untrained observers deems the air to be not objectionable under representative conditions of use and occupancy. An observer should enter the space in the manner of a normal visitor and should render a judgement of acceptability with 15 seconds. Each observer should make the evaluation independently of other observers and without influence from a panel leader.

(TEST GROUP STUDY)

2.0 SYSTEM AND EQUIPMENT

2.1 Ventilating systems may be mechanical or natural. However, due to the unpredictable nature of natural ventilation only mechanical ventilation complete with cooling should be used for electronic office environments. Also, provision for air flow measurement shall be included.

(MECHANICAL SYSTEM SPECIFICATION)

2.2 Ventilating systems shall be designed and installed so that the ventilation air is uniformly mixed throughout the occupied zone.

(MECHANICAL SYSTEM SPECIFICATION)

2.3 When the supply of air is reduced during times a space is occupied (e.g., variable air volume systems) provision shall be made to maintain acceptable indoor air quality.

(MECHANICAL SYSTEM SPECIFICATION/AIR SAMPLING AND ANALYSIS/ AIR FLOW RATE MEASUREMENT)

2.4 Make-up air (outdoor air) inlets shall be located to avoid contamination of the make-up air.

(MECHANICAL SYSTEM SPECIFICATION)

2.5 Exhaust air outlets shall be located so that exhaust air does not create a nuisance or contaminate make-up air.

(MECHANICAL SYSTEM SPECIFICATION)

2.6 Ventilating ducts and plenums should be constructed entirely of incombustible, nonporous materials.

(MECHANICAL SYSTEM SPECIFICATION)

2.7 Contaminants from sources within the space should be collected as close as practicable to the source and removed.

(MECHANICAL SYSTEM SPECIFICATION)

2.8 When it is necessary to remove particulate contaminants, air filters or dust collectors should be used.

(MECHANICAL SYSTEM SPECIFICATION)

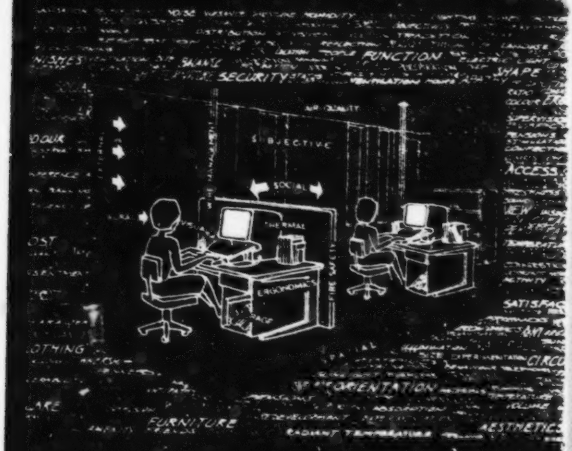
2.9 Where it is necessary to control gaseous contaminants, methods based on sorption with or without oxidation should be used. Such methods are usually specific to the type of contaminant. A commonly used sorbent is activated charcoal. Many odorous contaminants are readily oxidizable to less odorous substances, and can be controlled by passing the air through layers of pelletized oxidants such as alumina impregnated with potassium permanganate.

(MECHANICAL SYSTEM SPECIFICATION)

REFERENCE

American Society of Heating Refrigerating and Air Conditioning Engineers Inc. "Ventilation for Acceptable Indoor Air Quality ASHRAE 52-1981" Atlanta GA. 1981.

ELECTRONIC OFFICE DESIGN GUIDE


NOISE
HUMIDITY
DISTRIBUTION
FUNCTION
SHAPE
SECURITY
VENTILATION
AIR QUALITY
SUBJECTIVE
SOCIAL
THERMAL
ERGONOMICS
FIRE SAFETY
STORAGE
ACCESS
ORIENTATION
FURNITURE
RADIANT TEMPERATURE
AESTHETICS

FIRE SAFETY IN ELECTRONIC OFFICES

INTRODUCTION

Until recently, most fire regulations for buildings did not extend to furnishings and other contents brought in by the occupants. Concern about flammability of contents has, however, produced a number of regulations related to furniture flammability. This section of the Electronic Office Design Guide has been initiated to explore furniture flammability and current regulation concerning furniture flammability in order to develop performance requirements and criteria. These performance requirements are meant to supplement the performance standards, the National Fire Code of Canada and the Supplement No. 2 to the National Fire Code, as well as the Local Fire Safety requirements which relate more to the building itself than to the contents. The following review and recommendations are excerpted, *with permission from the Underwriters' Laboratories Study of 1977 and the First Generation Voluntary Standards of the Business and Institutional Furniture Manufacturers' Association 1980.*

PERFORMANCE REQUIREMENTS

1.0 Maximum fire safety requires a systemic approach which considers the entire environment. Accordingly, the following should be considered simultaneously:
   a) specification of fire-restraining waste containers;
   b) sprinkler systems;
   c) smoke and heat alarms;
   d) heating and ventilation systems designed to isolate smoke and heat;
   e) provisions for escape;
   f) fuel load standards; and
   g) fire safety educational programs.

2.0 SCREENING TEST, COMPONENT UPHOLSTERY MATERIALS

A test method to aid in screening individual materials, separate from end product construction shall be employed whenever possible to minimize total test load when used as a screening test for inspection of individual materials.

- CUSHION AND FILLER MATERIALS

2.1 If the average time of the flame spread for five specimens tested does not exceed 10 seconds, the materials shall not be acceptable. However, the time of flame spread for any single specimen shall be 7 seconds or more. (Less than 7 seconds shall constitute a failure.)

All cushion and filler materials shall meet the above requirements when tested as follows:

1. With and without any attached woven or nonwoven materials (i.e. scrims, sheeting, backings, carriers, etc.).
2. With the long dimension of specimens parallel to the width machine direction and parallel to the cross machine direction.
3. Before and after aging 24 hours at 220°F. Allow one hour at room temperature prior to testing.

(COMMERCIAL STANDARD 191-53)

- FABRICS, COVERINGS, TACKING MATERIALS

2.2 All fabrics, coverings and tacking materials shall meet requirements for NORMAL FLAMMABILITY, CLASS I.

(COMMERCIAL STANDARD 191-53)

- LOOSE FILLER MATERIALS

2.3 If or when utilized, loose filler materials must be contained in a covering or tacking of Class I flammability.

(COMMERCIAL STANDARD 191-53)

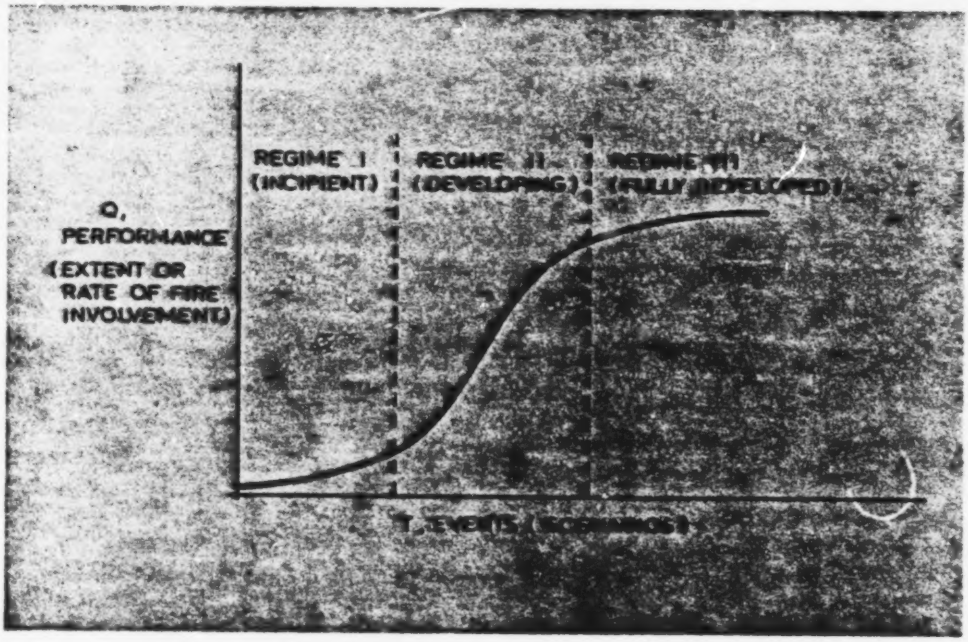
3.0 CIGARETTE IGNITION RESISTANCE

Cigarette ignition testing, of upholstered furniture and upholstered furniture reproduced in mock-up shall produce:

1. No obvious flaming combustion.
2. No char length greater than 75 mm in any direction measured from the nearest point of original cigarette location.

(COMMERCIAL STANDARD 191-53)

FIGURE 1



APPLICABLE TESTS

REGIME I	REGIME II	REGIME III
IGNITION TESTS	FLAME SPREAD TESTS	HEAT RELEASE RATE DETERMINATION
SMOLDERING	HEAT RELEASE RATE DETERMINATION	HEAT VALUE DETERMINATION
FLAMING		

S - CURVE REPRESENTATION OF BUILDING FIRE DEVELOPMENT

BASES FOR PERFORMANCE REQUIREMENTS

1. REVIEW OF THE FIRE EXPERIENCE IN OFFICES

Based on what statistics are available on numbers of fires, occupancy, suspected sources, fire origin, deaths, injuries, the role of upholstered furniture in office fires is diminishing. Although incomplete in many respects, the fire loss statistics reviewed by Underwriters' Laboratories indicated that "fires in offices do not account for a significant fraction of either fire deaths, fire losses, or fire incidents .... While furniture ignitions seem to account for a large proportion of residential fires and fire deaths, there is no indication that this is true for office fires."

Nevertheless, upholstered furniture represent a portion of the total fuel load in office occupancies, and some contribution to the overall fire hazard must be attributed to them, and the flammability characteristics of office furniture ought not to be completely ignored. However, in the development of flammability regulations for upholstered furniture, a distinction is necessary between residential and office furniture end-use occupancies. In the case of office and other non-live-in occupancies, an appropriate approach may be to establish regulations which prevent extremely flammable products from reaching the market and thus maintain the good fire record in these occupancies.

2. REVIEW OF REGULATORY APPROACHES:

Real fires progress through a series of stages. There are or may be several approaches to upholstered furniture flammability both in terms of the methods used to measure fire properties of furniture and in terms of the way in which those methods are used in regulations, which relate to various stages of fire development.

The stages of a fire's development have been quantified by the S-curve representation and description of events shown in Figure 1. The S-curve illustrates three regimes - incipient, developing, and fully developed fire conditions.

Regime I - Regime I concerns the period of fire development between the absence of any fire condition whatsoever, on through the initial introduction of an ignition source, and ending with the actual ignition of the item. Performance of an item in Regime I may be evaluated with the use of various ignition sources, such as a cigarette, or other smouldering source or by small flames. Ignition may also be evaluated with the use of flaming ignition source, a radiant ignition source or a combination of smouldering, flaming, and/or radiant ignition sources. Response of an item to one ignition condition does not necessarily indicate the response which may be anticipated with the use of another ignition source or combination of ignition exposures.

Regime II - This Regime deals with the performance of the item through the developing stage, from the period of apparent ignition, i.e., actual involvement of the item in the combustion process, and up to the condition of full involvement. Of concern through this regime are the spread of fire and flame and the production of smoke and toxic combustion products. The fire performance or flammability of the object in this Regime may be evaluated with a large specimen with a portion of the specimen exposed to an ignition source and observations of the time and distance relationship of fire growth from the exposed region into and/or along the unexposed region.

Regime III - This Regime considers the contribution of the furniture once a fully developed fire situation has occurred. In the fully developed fire situation, the considerations of concern are those related to the rate and total quantity of heat released by the actively burning item, as well as the smoke generated. Evaluation of characteristics important to the contribution of furnishing materials in this regard include methods which determine total potential heat available, methods which determine the rate at which heat is released by the burning material, and methods which develop information on smoke production.

From the regulatory viewpoint, the concepts of the stages of fire development, suggests three approaches to regulation as far as the occurrence and development of fire is concerned:

A) Control of ignition; i.e., ignition resistance,
B) Control of fire growth after ignition; i.e., flame spread, heat release,
C) Limit contribution to fully developed fire; i.e., fuel load, heat release.

Since smoke and combustion products development may occur through all phases of a fire, regulation might also consider these factors.

- Regulation on the basis of ignition resistance alone could provide control for only one regime, but may increase, decrease or have no affect on control of fire growth after ignition, fuel contribution in a fully developed fire, or production of smoke and other combustion products.

- Product modifications introduced to improve ignition resistance may result in increased propensity for smoke production.

- Fire tests of furniture pieces reveal that resistance to smouldering ignition bears little relation to the performance under growth or fully developed fire conditions.

- Tests performed on materials and constructions confirm materials or construction which have characteristics that prompt favorable performance under smouldering cigarette ignition exposure, may not perform so favorably under other ignition conditions, furniture construction conditions or fire conditions.

A variety of test methods has been developed and adopted by various regulatory bodies which deal with one or more of the above approaches. While there are many individual test methods in existence, each with its own particular specimen size and detail, test duration, and specimen performance specifications, there are five basic fire growth test configurations. They are:

1) Smouldering ignition tests (cigarette ignition)
2) Flaming ignition tests
3) Flame spread tests
4) Heat release rate tests
5) Heat value determinations

There are also several tests methods in existence for measurement of smoke production. In formulation of flammability standards for office furniture, these should be considered.

3. REVIEW OF TEST METHODS:

- SMOULDERING IGNITION TESTS

  The cigarette test involves placement of a freshly lighted, preconditioned cigarette on the specimen under test with or without a sheeting material covering the cigarette. Placement of cigarette has been shown to be critical, and specified locations include horizontal surfaces, crevices, seat cushions, welt edges, arm-rests, tops of backs, etc. Observations are made as to whether or not the specimen ignites and the extent of charring beyond the cigarette impingement area.

- FLAMING IGNITION TESTS

  These tests involve the use of a small flame from various laboratory type gas burners applied to test specimens for various periods of time. Materials evaluated by these various tests may include covering fabrics, padding, cushioning, or structural materials. These tests are used to measure ignition resistance to small flames and other fire characteristics such as burning rate, after flame, and char length.

- FLAME SPREAD TESTS

Radiant Panel

The radiant panel test (ASTM E162) provides a measurement of surface flammability of materials of many types. In this test, the specimen is exposed to a 300 x 450 mm radiant heat source in a nearly vertical position, ignition is forced by a pilot flame near the sample's upper edge, and any flame front which develops progresses downward. The rate of flame travel and the rate of heat liberation by the material are combined to provide a flame spread index.

Tunnel Test The tunnel test (ANSI/ASTM E-84, NFPA 255, UL723) is intended to measure surface burning characteristics (flame spread, fuel contributed and smoke developed) of various types of building materials. This test is used extensively by regulatory bodies for materials used in the construction of buildings.

This test utilizes a horizontal chamber 450 mm. wide, 300 mm high, and 8 m. long. the test specimen is mounted on the ceiling of the chamber and is exposed for 10 minutes to a methane gas diffusion flame over its fire 1.5 m. Observations are made of the maximum distance to which flames progress along the sample surface, fuel contribution by the specimen, and the amount of smoke produced.

Heat Release Rate Tests

Methods for measuring the rate of heat release by materials under firm conditions are under development. These have not yet achieved recognition by the national standards group, and no systematic application to furniture materials has been reported. The methods involve exposure of small samples to radiant energy and measurement of the heat contributed by the sample under those conditions. There are, however, significant differences between the methods and in their results.

- TOTAL FUEL VALUE

Apparently, the only existing procedures which addressed the burning behaviour of furnishings in fully-developed fires is used by General Services Administration (USA). It involves computation of the total fuel load contributed by the furniture, and limits the fuel load per unit floor area to a specified maximum. The fuel load is expressed as the equivalent weight of wood and is based on the weights of:

1) all combustible furniture components made of wood or celluiosic materials, and
2) all combustible components made of natural or other polymers other than cellulosics.

The equivalent fire load may be used to estimate the expected maximum fire severity in hours, and this is usually equated to the standard fire resistance rating required in the building construction. Common practice, based on the results of many fire tests, has been to relate the fuel load to the required fire resistance rating.

RECOMMENDATIONS

- **Fire Experience**

Fires in offices, are known to account for only a small fraction of all fires and fire casualties. Present data give no indication of the leading causes of such fires. Nevertheless, upholstered furniture does represent a portion of the fuel load present in office and ought not to be completely ignored. Such furnishings have an apparently good fire record overall, so that flammability regulation should at least endeavor to maintain the current level of fire performance, and particularly to identify and exclude exceptionally flammable new products.

- **Regulations and Test Methods:**

Regulations and test methods for furniture flammability which have been identified and reviewed encompass a wide range of test conditions and attempt to measure many different aspects of the fire behaviour of the materials involved. While many regulatory authorities involved may have obtained, through field experience, an appreciation for the practical significance of individual test results, it is not always obvious how the test procedures and the specified end points relate to real fire conditions of actual furniture items. Additionally, many of the tests are performed on individual furniture components, and performance of finished furniture items is not necessarily determined uniquely by such tests.

It appears to be worthwhile, therefore, to define test methods and acceptance criteria for the flammability of office furniture which address those aspects which seem to require control, in order to maintain the current level of fire performance. Even though hard data are not available from the fire statistics, it seems probable that at least the following five factors must be considered:

1. Resistance to ignition by cigarettes.
2. Resistance to ignition by open flames.
3. Contribution of fire growth through spread of flame.
4. Contribution of fire growth through heat release during fire build-up.
5. Contribution of heat to an established fire.

In addition, there is a need to consider smoke and combustion product development. In the final analysis, it may not be necessary to address all of these factors, but it is not obvious at present how each may be related to the overall fire record of office occupancies.

Only for the first factor, cigarette ignition, is there an existing test which bears a close relationship to actual conditions of usage. The cigarette ignition test would seem to satisfy the requirements for evaluating furniture flammability with respect to cigarette ignition causes. It is clear, however, that the cigarette ignition test would not provide any information concerning the other four factors.

Among the small-scale flame ignition tests described here, and numerous others which exist, a standard procedure can, no doubt, be found which can be related to the ignition potential of actual furniture. Establishing such a test procedure would require definition of the size of ignition source of interest, the form(s) of sample required, and the performance level desired. The ignition source may only be estimated at this point, but fire statistics which are currently being accumulated may well serve to identify the most prevalent, or perhaps the maximum, severity of flame ignition sources in office situations. The sample required should obviously be as nearly representative of the finished product as feasible, but it may be possible through research to define small samples or mockups which can be used instead of full-scale tests. Performance required should be determined through tests of existing furniture to identify the level of performance associated with the present state of affairs, for which the fire record is good.

Insofar as the ultimate consequences of fire are concerned, it would seem important that furnishings do not cause extremely rapid build-up of fire originating in or near the furniture. It may well be that this is the only requirement which needs to be placed on office furniture, since occupants will likely be awake and able to take action against fires. Both the radiant panel and the rate of heat release tests appear to have some relevance to this property of furnishings. Some effort would have to be devoted to determining sample configurations required and the desired level of performance. For the heat release rate determinations, the level of radiation to be imposed on the samples would have to be investigated as well.

The information presented suggests that a feasible approach to regulating the flammability of furniture in offices could be undertaken as follows:

1. Establish the Cigarette Ignition Test as a first generation standard for identifying easily ignited furniture materials.
2. Maintain continuous surveillance of fire data for information on causes of office fires and the role of furniture.
3. Establish an industry program to investigate the application of additional tests to supplement the cigarette ignition test, including:
   - A. A flame ignition test (correlating small scale tests of components with full-scale tests of furniture items).
   - B. The radiant panel test.
   - C. A rate of heat release test.
   - D. Smoke generation.
   - E. Composition of combustion products.

STUDY OF FIRE PERFORMANCE OF FURNITURE

One specific problem that might be singled out for immediate consideration is related to classification of fabrics within the ignition test. Published information suggests that all fabric within a certain class may be used interchangeably. However, the classification of the fabrics is predicted only by the cigarette ignition test. The performance under other fire exposure conditions is unknown, and the potential exists for solving one problem while creating furniture which has undesirable and unacceptable fire performance characteristics under other exposure conditions. This may be a compelling reason for development of test methods to evaluate furniture fire characteristics other than resistance to cigarette ignitions.

In general, in order to conduct further study of furnishings with respect to regime I ignition characteristics, tests should be conducted with materials, components, mockups, and finished furniture items in order to develop correlation between laboratory scale tests and the performance of actual end-use furniture pieces. In this regard, some preliminary testing may be in order, designed to develop information on current production furniture for which no adverse field fire performance is known. This would help to establish a datum against which subsequently introduced furniture items could be judged.

Once additional and satisfactory information has been developed with respect to ignition characteristics of furniture items for all the various ignition conditions represented in the Regime I fire phase, then test work can progress to evaluate the contribution of furniture items in Regime II, the fire growth Regime.

Tests in Regime II should consider multiple items in order to investigate the propensity for flame growth to occur from item to item. Further, contribution of the furniture items to development of flashover conditions, through involvement of either single or multiple furniture units, should be investigated. Such studies should be conducted within enclosed spaces, with measurement of temperatures within the room, heat generation by the furniture, energy feedback from the heated gases and room surfaces, and development of flashover conditions within the room.

Finally, tests in fully furnished rooms might be conducted in order to gain further insight into the role of upholstered furniture in fully developed fire situation, Regime III. However, the involvement of furniture in that environment could prove to be irrelevant if regulatory efforts are preoccupied with prevention of ignition, and minimization of the implications of ignition to preclude development of flashover.

- IGNITION CONSIDERATIONS

  At present, the period of fire growth which appears to be of greatest interest is the Regime I period in which the furniture first becomes ignited. Many studies to date have concentrated on the cigarette as the ignition source. Other ignition sources may bear equal consideration. Further research should include studies of various ignition sources, materials and test environments, with the objective of identifying the relationships of various ignition sources and conditions to the performance of upholstered furniture during the ignition fire period. A plan of investigation for exploring other ignition sources might be as follows:

A. Identify a variety of ignition sources,
   1) Match
   2) Small gas burner
   3) Crumpled newspaper
   4) Waste containers
   5) Radiant heaters
   6) Adjacent flaming furniture
   7) Other as appropriate.

B. Using mockups, determine burning response of a variety of materials in variety of combinations using different fabrics and padding materials. Measurements in these studies could include visual assessment of flame growth. Assessing the quantity of material involved in burning by visual observations may be combined with other measurements of the heat value of the materials to arrive at an assessment of the heat release rate of the burning material. Further, mockup tests could be conducted within enclosures representative of likely end-use environments, with provision for measurement of temperatures and smoke, in order to assess the role of furniture in the fire period leading up to the fully developed fire condition.

C. Conduct confirming test work on actual furniture pieces, using material and padding combinations identified in Step B above, as being of interest in the conduct of larger scale testing. Such testing could incorporate a variety of ignition sources with the furniture piece placed within a specified environment providing for visual observations of rate of involvement of the furniture piece. Additional measurements could be made with respect to smoke production and temperature rise developments.

- FIRE GROWTH CONSIDERATIONS

Growth of a fire is related to the way in which materials become involved in burning, as well as the way in which the fire condition developed by the burning of the materials is reflected or amplified by the enclosure or compartment in which the burning furniture material if found. A single piece of burning furniture will develop elevated temperatures and other unfavorable fire conditions in a small room much more rapidly than in a large open space. Thus, the growth of fire in furnishing items is related not only to the characteristics of the furnishing item itself but also the enclosure in which it is placed.

Tests to develop data on the contribution of furnishings in the fire growth period should include consideration of the environment. Extensive guidance for the conduct of such tests is provided by the ASTM "Recommended Practice for Room Fire Experiments."

To develop further information on this relationship, the following general test program may be appropriate:

A. Design an enclosure to incorporate:
   1) Variable heat capacity of walls,
   2) Variable wall, ceiling and floor finishing materials,
   3) Variable size,
   4) Variable ventilation conditions.

B. Create various fire conditions within the enclosure using a variety of:
   1) Furnishings,
   2) Furnishing combinations and quantity,
   3) Ignition conditions.

The objective of such testing would be to establish the relationship between the performance of furniture materials and pieces, under various laboratory tests such as flame spread tests and heat release rate evaluations and their performance in actual environments. In that performance is known to vary with changes in the environment, the relationship of fire performance to environmental changes is also to be established.

C. Determine performance of furniture materials and finished furniture by laboratory tests:
   1) Flame spread; E-84, E-162,
   2) Heat Release Rate; NBS Method, OSU Method.

D. Conduct comparative analysis of performance in fullscale and laboratory scale tests.

REFERENCES

1.0 The Business and Institutional Furniture Manufacturer's Association, BIFMA Flammability Standards Subcommittee, "First Generation Voluntary Upholstered Furniture Flammability Standard for Business and Institutional Markets" - Grand Rapids, Michigan 1980.

2.0 National Bureau of Standards "Commercial Standards 191-53 (Revised) Flammability of Clothing Textiles.

3.0 Underwriters Laboratories, Inc. Fact-Finding Reports; A Study of Existing Flammability Tests and Requirements for Upholstered Furniture: File R8044 Project 76NK5338, June 20, 1977.